Journal of Forestry Research (2012) 23(4): 553−568
DOI 10.1007/s11676-012-0295-8

ORIGINAL PAPER

Tree species diversity and stand structure along major community types in lowland primary and secondary moist deciduous forests in Tripura, Northeast India

Koushik Majumdar • Uma Shankar • Badal Kumar Datta

Received: 2011-05-04;   Accepted: 2012-05-14
© Northeast Forestry University and Springer-Verlag Berlin Heidelberg 2012

Abstract: Tree species diversity and population structure at different community types were described and analyzed for primary and secondary lowland moist deciduous forests in Tripura. Overall 10,957 individual trees belonging to 46 family, 103 genera and 144 species were counted at ≥30 cm DBH (diameter at breast height) using 28 permanent belt transects with a size of 1 ha (10 m × 1000 m). Four different tree communities were identified. The primary forests was dominated by *Shorea robusta* (mean density 464.77 trees·ha^{-1}, 105 species) and *Schima wallichii* (336.25 trees·ha^{-1}, 82 species), while the secondary forests was dominated by *Tectona grandis* (333.88 trees·ha^{-1}, 105 species) and *Hevea brasiliensis* (299.67 trees·ha^{-1}, 82 species). Overall mean basal area in this study was 18.01m^2·ha^{-1}; the maximum value was recorded in primary Shorea forest (26.21 m^2·ha^{-1}). Mean density and diversity indices were differed significantly within four different communities. No significant differences were observed in number of species, genera, family and tree basal cover area. Significant relationships were found between the species richness and different tree population groups across the communities. Results revealed that species diversity and density were increased in those forests due to past disturbances which resulted in slow accumulation of native oligarchic small tree species. Seventeen species were recorded with <2 individuals of which *Saraca asoka* (Roxb.) de Wilde and *Entada phaseoloides* (L.) Merr. etc. extensively used in local ethno–medicinal formulations. The present *S. robusta* Gaertn dominated forest was recorded richer (105 species) than other reported studies. Moraceae was found more speciose family instead of Papilionaceae and Euphorbiaceae than other Indian moist deciduous forests. Seasonal phenological gap in such moist deciduous forests influenced the population of *Trachypithecus pileatus* and capped langur. The analysis of FIV suggested a slow trend of shifting the population of Lamiaceae group by Moraceae species in secondary *T. grandis* L. dominated community.

Keywords: diversity and stand structure; moist deciduous forest; species conservation; tree community types

Foundation project: This work is financially supported by DBT Network Project (BT/PR7928/NDB/52/9/2006), Department of Biotechnology (DBT), Govt. of India.

The online version is available at http://www.springerlink.com

Koushik Majumdar • Badal Kumar Datta (✉)
Plant Taxonomy and Biodiversity Laboratory, Department of Botany, Tripura University, Suryamaninagar– 799130, Tripura, India. E–mail: dattabadal2008@gmil.com

Uma Shankar
Ecosystem Research Laboratory, Centre for Advanced Studies in Botany, School of Life Science, North– Eastern Hill University, Shillong – 793022, Meghalaya, India.

Responsible editor: Hu Yanbo

Introduction

Deciduous forests are considered as one of the most endangered major tropical ecosystem (Janzen 1986). Fire susceptibility during the dry season allows more rapid exploitation and conversion of these forests when compared to evergreen forests (Goldammer 1993). In the tropics, human settlements occur in areas of deciduous forests because of the more favorable climate. As expected, there is a positive correlation between the degree of forest disturbance and population density, while an inverse logarithmic relationship is observed between population density and the proportion of forested land (Bullock et al. 1995). In contrast to tropical rainforests, deciduous forests received relatively little scientific and political attention, whereas degradation and conversion of these forests are far more advanced (Bullock et al. 1995; Rundel and Boonpragob 1995). Secondary tropical forests develop where previous primary vegetation has been destroyed (Richards 1955; Brown and Lugo 1990) or partly modified and originating from selective felling (Sips 1993).

As primary forests have been increasingly kept as protected areas for environment and biodiversity conservation, the importance of the estimated 850 million ha of degraded and secondary forests has grown considerably in relation to their potential for wood production, environmental functions and support for the livelihood of local people (ITTO 2002). Distinguishing plant communities has been at the heart of vegetation science for cen-

turies, with a traditional focus on the distribution, composition and classification of plant communities (Kashian et al. 2003). Because, plant communities are separated from each other based on indicator species in combination with a distinctive floristic composition (Dansereau 1960) and trees form the major structural and functional basis of tropical forest ecosystem, can serve as robust indicators of changes and stressors at the landscape scale (Mishra 1968); which varies greatly from place to place, mainly due to variation in biogeography, habitat and disturbance (Whitemore 1993).

Across the world, 25 hot–spots have been identified on the basis of species endemism and degree of threat through habitat loss (Myers et al. 2000). Out of these, two are confined to India sub–continent i.e. Western Ghat and Sri Lanka & Indo–Burma. Tripura is the second smallest state of Northeast India and falls within the Indo–Burma hot–spot. So far, no quantitative research has been done to evaluate the plant diversity and stand structure across different forest types of Tripura state; although floristic investigation was carried out *ca*.40 years ago and published in the form of Flora in two volumes Deb (1981 & 1983). Some ethnobotanical studies were also conducted as the state is predominated by 19 ethnic groups (Majumdar et al. 2006; Majumdar and Datta 2007 & 2009).

In particular, quantitative information on tree species diversity and population structure across different forest formations were completely lacking for Tripura state. There was urgently need to generate information on compositional and structural attributes to update our existing strategies and thereby contribute knowledge to the understanding of the regional forest ecosystem for effective habitat management. In view of the above, the aim of this study were to: (1) firstly recognize the major tree communities in the study area, (2) test the differences in tree species diversity indices and stand structure across primary and secondary forest formations, (3) estimate tree species richness in different population groups and compare density–diameter classes distribution in different tree communities, (4) investigate disturbance directly or indirectly influenced existing community composition and structure, and (5) observe any possibility of changes in the family composition under the past disturbance regimes.

Materials and methods

Study area

Tripura is the second smallest State of North–east India with 10,491 km^2 geographical area and belongs to biogeographic zone 9B. The study area covers part of South and West districts, occurs between 23°30′–23°44′ N, and 91°15′–91°28′ E (Fig. 1). The elevation of the study sites range between 17 m to 83 m above mean sea level. The climate of this area is generally moist and humid. The minimum and maximum temperatures in summer are 21ºC and 38ºC. In winter it ranges between 4ºC and 33ºC. Humidity is generally high throughout the year. In the summer season the relative humidity differs between 50%–74% whereas in the rainy season it is over 85%. The mean wind speed is 7.1 km/hr, with maximum of 13.1 km/h in May and minimum of 3 km/h in December. The average annual rainfall varies between 1922 mm to 2855 mm and increased from South–west to North–east. The soil type of the study area is mainly red loam and sandy loam soils. The recorded forest area of the State is 6,294 km^2. Reserved Forest constitutes 66.33%, Protected Forest 0.03% and Unclassified Forests 33.64% of the total forest area. About 60% of the State's geographic area is under recorded forests (Anonymous 2009).

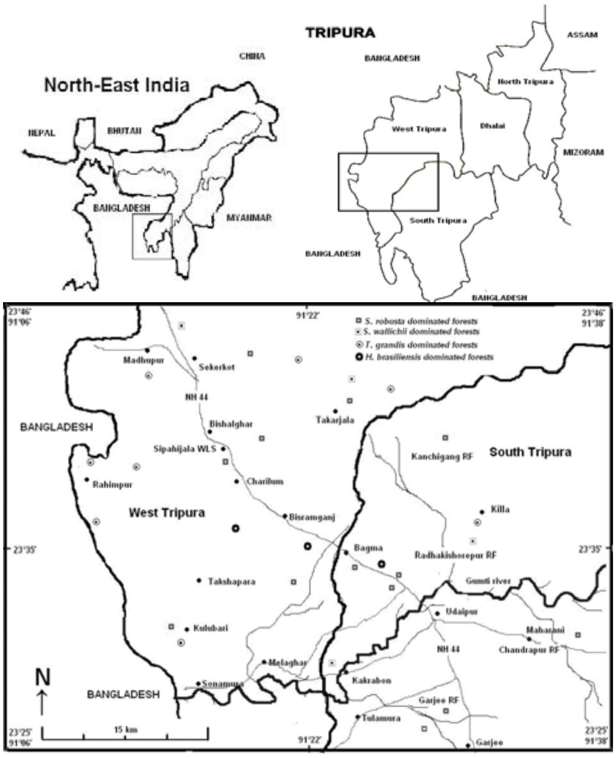

Fig. 1 Location of the study area in West and South Tripura, North–east India.

Based on classification system proposed by Champion & Seth (1968), Deb (1981) and Anonymous (2009) the existing primary native forests of Tripura can be classified mainly in four types viz. Cachar Tropical Semi Evergreen Forest (2B/2s2/c2), Moist Mixed Deciduous Forest (3C/C3), East Himalayan Lower Bhabar Sal (3C/C1b (ii) and Moist Bamboo Brakes (2B/E3). The secondary forests can be categorized into the degraded form of Northern Secondary Moist Mixed Deciduous Forest (3C/2s1), Low Alluvial Savanna Woodland (3B/E3) and Secondary Moist Bamboo Brakes (2B/1S1). While, the State is inhabited by 19 different types of ethnic groups (Anonymous 1956) and shifting cultivation is deeply integrated into the social, cultural, and economic lifestyle of many tribal groups that constitute about 31% of the total population of the state. Out of a total of 55,049 *Jhumia* (shifting cultivator) households all over the State, 21,677 (39.3%) are entirely dependent on *Jhuming*, and the remaining

60.7% are partly dependent (Gupta 2000). Thus, *Jhuming* and several other anthropogenic factors enhanced the modification of those primary forests wholly or partially into secondary degraded vegetation. However, several types of plantation viz. *Tectona grandis*, *Gmelina arborea*, *Sizygium* spp., *Hevea brasiliensis*, *Cassia* spp., *Lagestromia* spp., *Shorea robusta*, *Dipterocarpus turbinatus*, *Anacardium occidetalis* etc. and several bamboo species were developed slowly by Forest Department since 1887 for rehabilitation of degraded forest (Chakraborty 1985; Anonymous 2000). Thus, the rehabilitated forests are now representing the features of northern secondary moist mixed deciduous forest, especially the miscellaneous plantation with native trees. The low alluvial savanna woodland represents especially the plantations developed by monoculture on degraded land. Extensive jhuming and bamboo flowering in many moist bamboo brakes resulted at different succession level into secondary moist bamboo brakes.

The native moist deciduous Sal forest is distributed extensively in the South district and part of West district extending to the border of Bangladesh. The present study area covered a large portion of this forest types which included four Reserved Forests (RF) viz. Garji RF, Chandrapur RF, Radhakishorepur RF and Kanchigang RF; located in Bagma, Joyalikhamar, Kalabon, Tepania, Chailtachara of South Tripura district and Motinagar, Charilum, Latiachara, Champamura, Jumerdhepa, Mohanbog, Kuffilong and Ratanpur of West Tripura district. The moist deciduous mixed forests cover very large area of the State and differ from the moist deciduous Sal forest on the absence of Sal or its scarcity, which dominated by *S. wallichii* surveyed in four location viz. Silghati, Nowagong of South Tripura and Hirapur, I.C.Nagar of West Tripura district. Instead of Teak is indigenous to India, Myanmar, Thailand, Laos and well developed within temperature ranges between 9–41ºC with annual rainfall of 1300–3800mm and dry periods of 3–5 months (White, 1991). While, teak might be introduced in Tripura during National Aforestation Programme (Chakraborty 1985; Anonymous 2000) for quick restoration of those degraded forests. The present study area falls within its wide geographic distribution range and the primary populations develop heritable adaptations to local environmental factors in order to survive and regenerate in degraded forest. The present study included eight Teak dominated forests located in Kalsimura, Madhupur, Haikantapara, Khedabari, Putia, Kulubari, Rangapania of West Tripura district and Killa of South Tripura district. *H. brasiliensis* was first introduced in Tripura on experimental basis during 1912 and since 1960 it did not receive much response and thereafter its large scale plantation started (Deb 1981) and revolutionary increased during last ten years under both private and public sectors. The *Hevea* plantation being totally monoculture by completely clearing previous forest stands and managed regularly for latex collection, so the inside tree diversity is very low with few scattered *A. procera, A. chinensis, A. chama* etc. and left for shade and timber requirements. But adequate tree diversity still exists at the marginal fragmented forests. This group of tree community was sampled at Nayachara of South Tripura; Rangmala and Tujhiling of West Tripura district (Fig. 1).

Field data collection

Tree community data were collected during 2007 to 2008 from 28 permanent belts transects at ≥30 cm diameter over bark at breast height at 1.3 m (DBH). Each belt transect was 1 ha (10 × 1000 m), encompassed ten 10 × 100 m contiguous sub–plots and placed in such way that it can cover maximum habitat heterogeneity of tree community. Thus, data were obtained from total 28 ha which represented two primary major tree communities of *S. robusta* dominated moist deciduous forest (13 ha) and *S. wallichii* dominated moist mixed deciduous forest (4 ha). The secondary groups were old *T. grandis* plantation developed by the Forest Department on degraded forests (8 ha) and 10–12 years old *H. brasiliensis* plantation including its adjacent fragmented forests (3 ha). Teak and Para–rubber plantations were selected as secondary tree communities for the study being the existing major plantation landscape of the State. As Para–rubber plantation is totally monoculture, so the belt transect was placed in such way that it could give a clear idea of the present status of tree diversity inside the plantation and its marginal forest patches. The Bamboo and *Musa* species eschewed during the sampling. The woody climber that attained at ≥30 cm diameter category was also considered as tree. The GPS location of each transects were noted and all individual trees diameter were measured in centimeter and height at nearest meters in living and non–living categories. The non–living categories included cut or logged and dead trees. Specimens were identified with the help of The Flora of Tripura State (Deb 1981–1983) and the Flora of Assam (Kanjilal et al. 1934–1940). The reference herbarium was deposited in herbarium of Botany Department, Tripura University.

Analysis

The tree community data were quantitatively analyzed for relative frequency, relative density, relative basal area and Importance Value Index (IVI) following Mueller–Dombois and Ellenberg (1974). Species diversity for each forest type was determined as Shannon and Weiner (1963) and the index of dominance of the community was calculated by Simpson (1949). The index of species richness was measured by Menhinick (1964) and evenness of the community was calculated by Pielou (1966). The number of individuals and richness of tree species were grouped into different population groups viz. Predominant (>50), Dominant (25 to <50), Common (10 to <25), Rare (2 to <10) and Very Rare (<2) (Kadavul and Parthasarathy 1999). The tree density was also grouped among different diameter classes (≥30–60, 60–90, 90–120, 120–150, 150–180, 180–210, 210–240, 240–270, >270 cm) to observe distribution of trees among different diameter or age classes. The number of cut or logged and dead trees was counted as the percentage of total number of trees ha^{-1} for quantitative disturbance index (Rao et al. 1990; Pandey and Shukla 1999). The Family Importance Value (FIV) was determined as Ganesh et al. (1996). The significance of differences in diversity indices, density and basal area among the four communities were statistically tested using one–way analysis of variance

(ANOVA) and *t*–test. The relationship between the species richness (y) and number of individual in different population groups (x) were examined by curve fitting. The patterns of major family composition and tree community types were examined across 28 plots using non–metric multidimensional scaling (NMS) ordination based on Gower similarity. All statistical analysis was performed by PAST version 1.89 (Hammer et al. 2001).

Results

Overall tree species richness and diversity

Altogether, within 28 belt transect inventory totally 10,957 individuals were counted at ≥30 cm DBH and 144 tree species of 103 genus and 46 families were recorded. The observed number of species was recorded greatest both in primary Shorea community (105 species; 39 families) and secondary Teak community (105 species, 40 families). The primary Schima dominated community had 82 species belonging to 37 families and 63 species with 29 families from secondary Hevea dominated community. The number of observed species (F=2.35, df=3, 24; p=0.09), genus (F =2.03, df=3, 24; p=0.13) and family (F =2.12, df=3, 24; p=0.12) in four community types did not vary significantly. Furthermore, results of the *t*-test also suggested that number of species (t =2.23, df=19; p=0.04) was significantly greater in primary Shorea community than secondary Hevea community and number of family (t =2.21, df=9; p=0.05) was significantly greater in Teak community than Hevea community (Table 1). Mean Shannon's diversity was 3.00 (range 1.76 to 3.57), which was maximum in case of secondary Teak community (3.39) and recorded minimum in case Shorea community (2.75). The overall mean Menhinick's species richness index was 1.49 (range 0.54 to 2.12), which was greatest in Teak community (1.88) and lowest in primary Shorea community (1.22). However, Shannon–Wiener diversity (F =4.12, df=3, 24; p=0.01) differed significantly among the tree community types and more significant between Shorea and Teak communities (t =3.17, df=19; p=0.005), Teak and Hevea communities (t =2.66, df=9; p=0.03). Menhinick's species richness (F =4.92, df=3, 24; p=0.008) also differed significantly among the studied communities and greater in case of Shorea and Teak communities (t =3.46, df=19; p=0.002). Mean Simpson's dominance index was 0.10 (range 0.04 to 0.30), which was maximum in both Shorea and Hevea community (0.13) and minimum in case of secondary Teak community (0.05); which did not show significant difference (F =4.12, df=3, 24; p=0.06) within communities but significantly differ between Shorea and Teak communities (t =2.67, df=19; p=0.01). The overall Pielou's evenness index was 1.88 (range 1.46 to 2.10); which recorded high in secondary Teak community (2.03) and low in case of Shorea community (1.77), (t =3.31, df=19; p=0.004); which was significantly differed among the communities (F =5.07, df=3, 24; p=0.007). The overall mean stand density was recorded 391.32 trees ha^{-1} (range from 199 to 667 trees·ha^{-1}) and was significantly greater (F =3.18, df=3, 24; p=0.04) in primary Shorea community (464.77 ha^{-1}) than that in secondary Hevea community (299.67 ha^{-1}). Whereas, density of Schima and Teak communities were significantly lower than primary Shorea community (t =2.31, df=19; p=0.03 and t =2.05, df=14; p=0.05 respectively) (Table 1). Mean basal area for all four groups was recorded 18.01 m^2·ha^{-1} and was maximum for Shorea community (26.21 m^2·ha^{-1}) and minimum in case of Hevea community (10.57 m^2·ha^{-1}) which did not vary significantly among the tree community types (F =1.73, df=3, 24; p=0.18); but significantly greater in Shorea community than Hevea community (t =2.53, df=19; p=0.02) (Table 1).

Table 1. Summary of forest structure across all plots in four different tree community types in Tripura

Tree Community	types	No. of belt transects (n)	Observed Species	Genus	Family	Density (trees·ha^{-1})	Basal area (m^2·ha^{-1})	Shannon's Diversity Index	Simpson's Dominance Index	Pielou's Evenness Index	Menhinick's Speciess Richness
Primary Forest	Sal dominated	13	37.15 ± 11.04 (105)a	34.08 ±9.56 (79) a	23 ± 4.73 (39)ab	464.77 ± 118.69 (6042)a	26.21 ± 24.82a	2.75 ± 0.46a	0.13 ± 0.07a	1.77 ± 0.18a	1.22 ± 0.34a
	Schima dominated	4	40 ± 3.92 (82)ab	35.75 ±3.40 (64)a	24.25 ± 1.50 (34)ab	336.25 ± 123.19 (1345)ab	11.47 ± 3.16ab	3.12 ± 0.28ab	0.08 ± 0.04ab	1.95 ± 0.14ab	1.59 ± 0.26ab
Secondary Forest	Teak dominated	8	47 ± 4.31 (105)b	41.13 ±2.95 (78)a	26.25 ± 1.28 (38)a	333.88 ± 112.67 (2671)b	10.76 ± 2.32b	3.39 ± 0.17b	0.05 ± 0.02b	2.03 ± 0.07b	1.88 ± 0.27b
	Havea dominated	3	33.33 ± 15.82 (63)ab	29.67 ±12.10 (52)a	20.33 ± 5.69 (28)b	299.67 ± 127.47 (899)b	10.57 ± 5.58ab	2.85 ± 0.75a	0.13 ± 0.12ab	1.90 ± 0.22ab	1.49 ± 0.83ab
	Overall	28	39.96 ± 10.13 (144)ab	35.86 ±8.31 (103)a	23.82 ± 4.06 (46)ab	391.32 ± 131.91 (10957)ab	18.01 ± 8.41ab	3.00 ± 0.48a	0.10 ± 0.07ab	1.88 ± 0.19a	1.49 ± 0.46a

Classification of tree community

Based on maximum contribution to IVI, the following major four tree communities have been recognized. The primary tree community consists of moist deciduous forests dominated by *S. robusta* and moist mixed deciduous forests dominated by *S. wallichii*. The secondary communities were grouped based on two major old plantations dominated by *T. grandis* and *H. brasiliensis*.

S. robusta dominated community (Shorea community)

This primary native tree community was characterized by moist deciduous forest and dominated by *S. robusta*, which was represented by 13 belt transects. A total of 6,047 individual trees with mean density of 464.77 trees ·ha $^{-1}$ (range 310–667 trees·ha^{-1})

were counted at ≥30 cm DBH. The mean basal area was 26.21 $m^2 \cdot ha^{-1}$ (range 10.59–101.68 $m^2 \cdot ha^{-1}$). A total of 105 species of 79 genus and 39 families was recorded. The mean Shannon–Wiener diversity was recorded 2.75 (range 1.76–3.37); whereas the mean Simpson dominance was 0.13 (range 0.05–0.03), Pielou evenness index (1.77) and species richness (1.22) was recorded (Table 1). The top storey canopy of this association was dominated by *S. robusta*, *C. arborea*, *T. bellirica*, *D. pentagyna*, *S. personatum, B. ceiba* and occasionally *A. chama* and *D. turbinatus* were also found. The mid storey canopy was dominated by *L. parviflora, L. coromandelica*, *S. cerasoides*, *A. procera*, *A. chinensis* and occasionally by *A. acuminata*. The under storey was dominated by *M. paniculata*, *H. anidysenterica*, *B. retusa*, *M. rotundifolia*, *V. peduncularis*, *C. castanicarpus*, *M. phillippensis*, *M. denticulate* etc. *S. robusta* had highest density (156.85 $trees \cdot ha^{-1}$) followed by *C. arborea* (25.92 $trees \cdot ha^{-1}$) and basal area for *S. robusta* and *C. arborea* was 9.66 $m^2 \cdot ha^{-1}$ and 3.44 $m^2 \cdot ha^{-1}$, respectively. The top ten predominant species contributed 64.70% of total density and 74.81% of the basal area. Maximum IVI was recorded for *S. robusta* (70.66) and 163 for top ten predominant species (Appendix–I).

S. wallichii dominated community (Schima community)

The second primary group of tree community was moist mixed deciduous forest and based on the absence of Sal it was separated from the previous type. This community represented 82 species belonging to 64 genus and 34 families. A Total 1,345 individual trees were counted with mean density of 336.25 trees $\cdot ha^{-1}$ (range 271–521 trees ha^{-1}) and mean basal area was 11.47 $m^2 \cdot ha^{-1}$ (range 7.52–14.37 $m^2 \cdot ha^{-1}$). The mean Shannon –Weiner diversity was 3.12 (range 2.77–3.43); Simpson's dominance was recorded 0.08 (range 0.05–0.15) and the mean Pielou evenness was 1.95 and Menhinick's species richness was 1.59 (Table 1). The canopy storey of this community was not prominent and *S. wallichii* was predominant tree. The top storey canopy was unevenly about 20–25 m high; *S. wallichii, T. bellirica*, *C. arborea*, *D. pentagyna*, *L. parviflora* etc. and occasionally *A. chaplasaha* and *S. cerasoides* etc. were the dominant tree species. The mid storey was dominated by *B. malabrica*, *L. coromandelica*, *V. peduncularis,* etc. The lower storey was colonized by *H. antidysenterica*, *G. assamica* and *M. paniculata,* etc. The ten top most dominant tree species were *S. wallichi*, *B. malabarica*, *T. bellirica*, *C. arborea*, *H. anidysenterica*, *L. coromandelica*, *L. parviflora*, *S. cerasoides*, *G. assamica* and *M. paniculata,* occupying 57.39% density and 62.41% of basal area. Alone *S. wallichi* had a density of 85.25 trees $\cdot ha^{-1}$ and the basal area of 3.65 $m^2\ ha^{-1}$ followed by *B. malabarica* 21 trees $\cdot ha^{-1}$ and 0.55 $m^2\ ha^{-1}$. The top ten predominant species contributed IVI of 155.94 and alone *S. wallichi* had 64.30 followed by *B. malabarica* (14.66), *C. arborea* (12.71), *T. bellirica* (11.63*) and L. coromandelica* (11.02) (Appendix–I).

T. grandis dominated community (Teak community)

This group of secondary tree community represented secondary *T. grandis* dominated community. The present Teak community was degraded form of primary forest where major parts were modified approx. 35–40 years ago by the Forest Department. A total of 8 ha plot included 105 species belonging to 78 genus and 38 families. Total 2,671 individuals were measured with mean density of 333.88 ha^{-1} (range 199–552 $trees \cdot ha^{-1}$) and mean basal area recorded 10.76 $m^2 \cdot ha^{-1}$ (range 7.16–14.57 $m^2 \cdot ha^{-1}$). The mean Shannon –Weiner diversity was 3.39 (range 3.01–3.57), Simpson's dominance was recorded 0.05 (range 0.04–0.10), mean Pielou evenness was 2.03 and Menhinick's species richness was recorded 1.88 (Table 1). The canopy layers of this association were not conspicuous and the upper storey was dominated by *T. grandis, T. bellirica, L. coromandelica, A. acuminata, L. parviflora, M. rotundifolia* etc. and H. *antidysenterica*, *B. malabarica*, *M. paniculata* and *M. philippensis* etc. forming the subcanopy layers. *T. grandis* had a higher density of 37 $trees \cdot ha^{-1}$ and a basal area of 1.17 $m^2 \cdot ha^{-1}$ followed by *H. anidysenterica* (30.62 $trees \cdot ha^{-1}$ density and 0.52 $m^2 \cdot ha^{-1}$ basal area). The top ten predominant trees encompassed 44.81% of total density and 50.07% of total basal area. About 11.01% density of this community was predominated by *T. grandis*, followed by 9.17% *H. anidysenterica*, 4.90%, 4.86% and 3.70% by *T. bellirica*, *L. coromandelica* and *L. parviflora,* respectively. The top ten predominant trees had IVI of 127.07; of which alone *T. grandis* had 26.44 followed by *H. antidysenterica* (18.16), *A. chama* (15.87), *T. bellirica* (13.63) and *L. parviflora* (11.50) (Appendix–I).

H. brasiliensis dominated community (Hevea community)

This group of secondary tree community represented the degraded form of moist mixed deciduous forest where a major part of such forest fragments were replaced with extensive Para–rubber plantation. A total of 899 individual stem of 63 species, 52 genus, and 28 families with mean density of 299.67 $stems \cdot ha^{-1}$ (range 199–443 $stems \cdot ha^{-1}$) and basal 10.57 $m^2 \cdot ha^{-1}$ (range 5.90– 6.75 $m^2 \cdot ha^{-1}$) were recorded from this community. The mean Shannon–Weiner diversity was 2.85, whereas Simpson dominant index was 0.13, Pielou evenness was 1.90 and Menhinick's species richness was 1.49 (Table 1). Alone, *H. brasiliensis* represented 36.81% of total density (110.33$\cdot ha^{-1}$) and 44.95% of total basal area (4.75 $m^2 \cdot ha^{-1}$). The marginal fragmented forests of this community still had valuable tree diversity and canopy storey was more or less similar to the moist mixed deciduous communities. *A. chama, L. coromandelica, L. parviflora*, *H. anidysenterica, T. bellirica, S. cerasoides, M. paniculata, C. arborea* etc. were found scattered within this community. The top ten predominated trees contributed 70.85% of density and 75.45% of basal area. The top ten predominant tree had IVI of 183.27; of which 88.73 was for *H. brasiliensis* followed by *A. chama* (15.59), *L. coromandelica* (14.67), *L. parviflora* (13.76) *and H. anidysenterica* (10.55) (Appendix–I).

Tree community dominance and rarity

For primary Shorea community the predominant group represented 25 species with 86.06% of total individuals, 12 dominant species with 7.16% individuals, 13 common species with 3.59%

individuals, 39 rare species with 2.91 individuals and 16 very rare species with 0.26% individuals. In case of Schima community both the predominant and dominant groups had only six species each with 48.55% and 15.09% of total individuals respectively, 20 common species contributed 22.60% of individual, rare 13.16% with 42 species and very rare 0.59% with eight species. The predominant group in secondary Teak community contributed 55% with 14 species, dominant 19 species with 25.72%, common 12.24% with 20 species, and rare 6.44% with 36 species and very rare represented 0.60% with 16 species. In Hevea community the predominant group had only two species with 42.71% of total individuals, seven species represented the dominant group with 26.59%, eight species were found common with 12.68%, 36 species represented rare group with 16.91% and 1.11% individuals were very rare group with 10 species. The relationship between the number of individuals and species in all four communities were positively correlated among five groups. The number of individuals and species richness within the predominant groups showed significant quadratic relationship among the four different tree communities (r^2_{adj}=0.99; p<0.05) (Fig. 2a). While for the dominant (r^2_{adj}=0.99; p<0.001) and very rare (r^2_{adj}= 1; p<0.001) groups the individuals were linearly related with species richness within four different tree communities (Fig. 2b & 2e). Linearly increasing pattern was also found between the individual and species richness in case of common group (r^2_{adj}=0.98; p<0.05); but in case of rare group this relation was curvilinear and not significant (r^2_{adj}=0.93; p>0.05) (Fig. 2c & 2d).

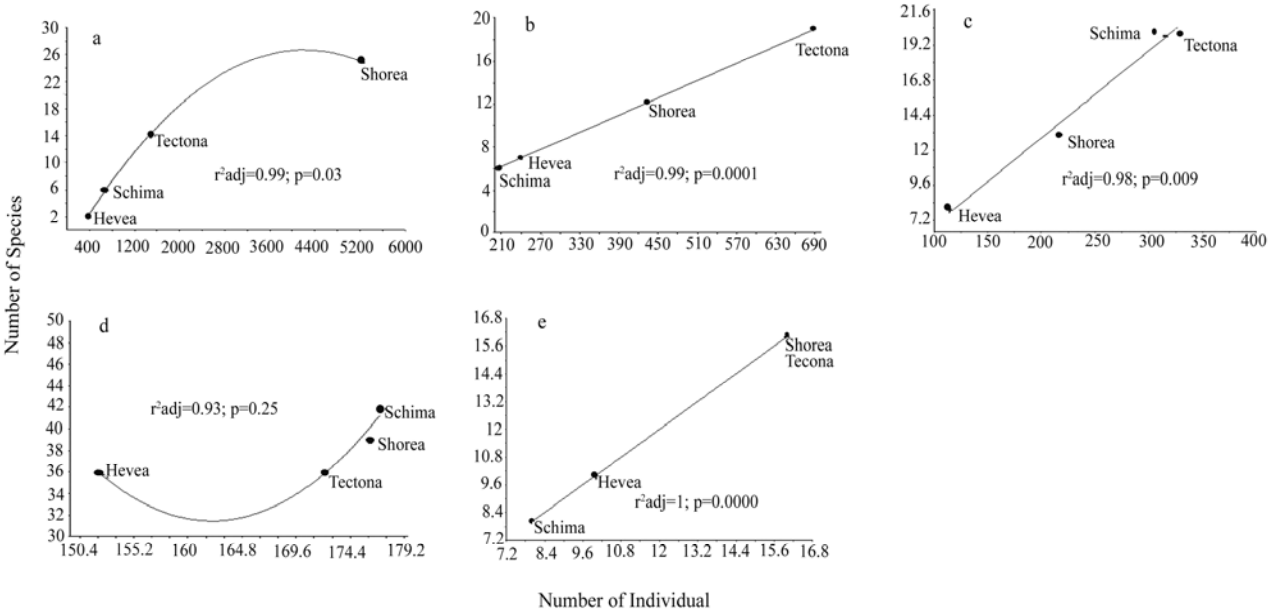

Fig. 2 Relationship between species richness and individual in four different tree communities. Individual are grouped into a. Predominant, b. Dominant, c. Common, d. Rare and e. Very Rare.

Tree community stand structure and diameter class distribution

All four tree communities exhibited multimodal tree size structure with monotonically increased concentration of trees in the smallest diameter class and with increasing tree diameter classes the number of stem decreased drastically at >120 cm in all communities except for Shorea dominated community. The size classes distribution of trees among the four communities exhibited reverse J–shaped (Fig. 3). Tree density of smallest diameter class of ≥30–60 cm was greater (63.42%) in secondary Teak community followed by 63.30% in primary Schima community, 58.36% in primary Shorea community and lowest (49%) in Hevea community; this proportion decreased with increasing tree size classes. Density of trees in highest diameter class (>300 cm) was maximum in Shorea community (0.55%; 2.54 trees·ha^{-1}) followed by Schima community (0.37%; 1.25 trees·ha^{-1}), Teak dominated secondary stands (0.11%, 0.38 trees·ha^{-1}) and Hevea dominated secondary stands (0.11%, 0.33 trees·ha^{-1}). All diameter classes were observed to present in case of Shorea community and Teak dominated community, but diameter classes >210 cm and 240–270 cm were completely absent in case of Hevea and Schima dominated communities respectively. The density of mature trees (>120 cm) were highest in case of Shorea dominated community (49 trees·ha^{-1}) followed by Schima (8.25 trees·ha^{-1}), Teak (7.88 trees·ha^{-1}) dominated forest and lowest in Hevea dominated community (5 trees·ha^{-1}).

Disturbance Index (DI)

Overall 57.24 trees·ha^{-1} were recorded as logged and 9.73 trees·ha^{-1} were in dead condition and hence total DI value was recorded 18.78 for whole study. Maximum DI was recorded for secondary Teak community (5.09) and was low for primary Shorea community (4.37). Maximum number of logged trees were

recorded in secondary Teak community (4.61%) followed by 3.94% in primary Schima community, 3.79% for Shorea community and 3.67% for Hevea community. Whereas, maximum number of dead trees were recorded for Hevea community (0.89%) followed by Schima community (0.82%), Shorea community (0.58%) and Teak community (0.49%) (Table 2).

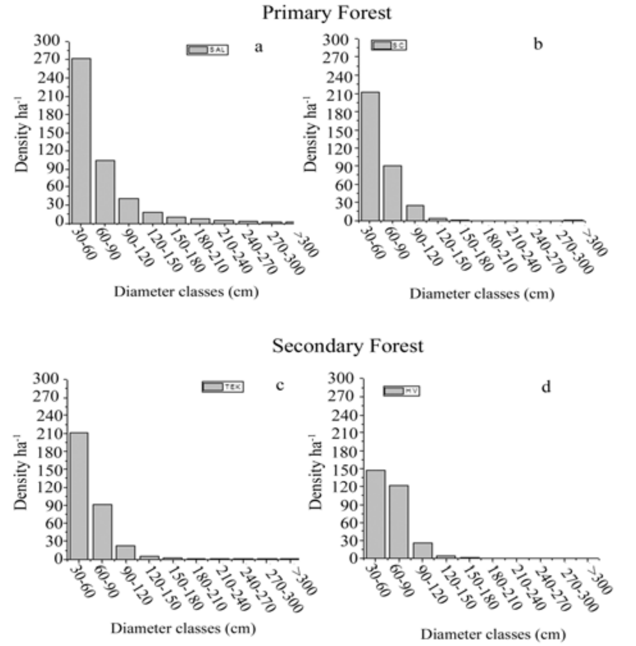

Fig. 3 Density–diameter distribution of tree population in four different communities of primary and secondary forests. (a. Shorea community, b. Schima community, c. Teak community, d. Hevea community.)

Table 2. Disturbance Index (DI) in four different tree communities of Tripura.

Tree communities	Trees ha^{-1}				
	Cut	Dead	Live	Total	DI
Sal dominated community	17.62	2.69	444.46	464.77	4.37
Schima dominated community	13.25	2.75	320.25	336.25	4.76
Teak dominated community	15.38	1.63	316.88	333.88	5.09
Havea dominated community	11	2.67	286	299.67	4.56
Overall	57.24	9.73	1367.59	1434.56	18.78

Variation in tree family compositions and Family Importance Value (FIV)

Overall 46 families were recorded for the present study. Primary Shorea community had maximum 39 families followed secondary Teak community (38), Schima community (34) and Hevea community (28). For Shorea community family Moraceae contributed maximum species richness (12). The top five predominant families contributed 61.96% of total density for Shorea community and predominated by Dipterocarpaceae (36.24%), Lamiaceae (6.81%), Moraceae (6.58%), Combretaceae (6.55) and Euphorbiaceae (5.75); which shared 163.31 of the sum of FIV. In case of primary Schima community the top five families contributed 27 species, where Moraceae (8) was the most individualized family. About 52.49% of total density was represented by Theaceae (25.35%) followed by Euphorbiaceae (9.66%), Caesalpinaceae (6.24%), Combretaceae (5.65%) and Myrtaceae (5.57%). Theaceae contributed 31.84% of total basal area and top five predominant families contributed sum of FIV 139.48. Lamiaceae was the most densities family with 14.98% of total individuals followed by Moraceae (9.80%), Apocynaceae (9.39%) and Euphorbiaceae (8.66%) respectively for secondary Teak community. About 52.07% of the total basal area was represented by top five predominant families with contribution to FIV of 131.48. Out of 63 species, 23 species belong to top five predominant families in secondary Hevea community. Euphorbiaceae was the most densities family with 41.15% of individuals and 47.31% of the total basal area represented by top five families and shared 179.31 sum of the total FIV (Appendix–II).

The NMS ordination of the 46 families using 28 plots across different tree community types by Gower similarities on species richness, density and basal cover area acquiesced two dimensional solution with a minimum stress value of 0.05 (Fig. 4). Four different tree community types could be distinguished in the ordination based on representative predominant family (Dipterocarpaceae for Shorea community, Theaceae for Schima community, Euphorbiaceae for Hevea community and Moraceae for Teak community) with axes scores of all 46 families (Appendix–II). Out of 46 families, 31 families positively and 15 families placed negatively on axis–I; 17 families negatively and 29 families placed positively on axis–II.

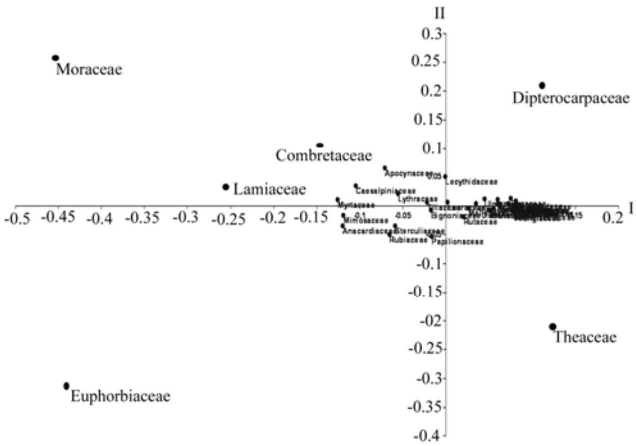

Fig. 4 NMS ordination of 46 families based on species richness, density and basal cover area from four different tree communities of primary and secondary forest of Tripura.

Discussion

Tree community types and diversity

The present analysis of low land moist deciduous forests in the study area identified four major tree communities predominated by four different deciduous trees. However, the comparison of present analysis with other tropical forests may have been af-

fected due to differences in sampling methodology, forest age, geographical, climatic and other local biotic factors. The number of observed species, genus and families did not vary significantly under four different tree communities due to plots proximity and less habitat heterogeneity in terms of mean annual rainfall and other edaphic factors. Because, formation series, edaphic factors as well as annual rainfall are responsible for differences in forest structure (Beard 1955). Total 144 species belonging to 103 genus and 46 families were recorded within the 28 ha plot and range 63–105 species from primary to secondary forest formations. The present range of species was higher than the range (35–90) reported for dry tropics (Murphy and Lugo 1986). Since, species diversity doubles from dry to moist forest (Holdridge 1967) and the present forest types range from moist deciduous to moist mixed deciduous forests. The overall mean tree density 391.32 trees·ha^{-1} (range 199–667 trees·ha^{-1}) at ≥30 diameter class was well within the limit of tropical forests 245–859 trees·ha^{-1} (Richards 1955; Ashton 1964; Campbell et al. 1992) and mean basal area 18.01 m^2·ha^{-1} was very close to basal area of dry tropics 17–40 m^2·ha^{-1} (Murphy and Lugo 1986), 24.2 m^2·ha^{-1} (Poore 1968), 25.5 to 27 m^2·ha^{-1} (Campbell et al. 1986 and 1992), 27.6 to 32 m^2 ha^{-1} and pantropical average of 32 m^2 ha^{-1} (Dawkins 1959). The diversity indices were also well with in the reported range for the forests of the Indian sub–continent (Jha and Singh 1990; Ayyappan and Parthasarathy 1999; Chittibabu and Parthasarathy 2000; Pandey and Shukla 2003; Bhuyan et al. 2003; Kumar et al. 2006).

Uma Shankar (2001) reported Shorea forest as species rich in Eastern Himalayan region. The present species richness in Shorea forest with 105 species was higher than Eastern Himalayan (87) and Central Indian (93) Shorea forest (Pandey and Shukla 2003). The high species richness in the present Shorea forest may be attributed to low altitude, higher plot number, size and variation in climatic or biotic factors in contrast to other reported Shorea forests. 105 species were also recorded in the secondary Teak community, which may have been due to its proximity to the primary forest and less competitive stress of Teak than Shorea. The diameter classes based selective logging was also evident from the maximum DI value (5.09) in Teak community, which created gaps in the stand and hence reducing competition for water and nutrients (Denslow et al. 1980; Sapkota et al. 2009) enhanced the accumulation of both light and shade loving species in those Teak dominated community. However, increasing the biological diversity has been reported in the plantation due to the successional development of understorey into middle canopy (Lugo 1997; Parrrotta et al. 1997; Powers et al. 1997; Carnevale and Montagnini 2002). The present species richness of Teak community was greater than Saha (2001) with 46 tree species in Teak plantation from dry deciduous forest of Central India; 37 species by Koonkhunthod et al. (2007), 46 species by Neeranathpibul and Sangtongpraow (2002) at >4.5cm DBH, 13 to 43 year old plantation; Kaewkrom et al. (2005) recorded 59 species from 12 year old plantation and Bunyavejchewin (1984) with 68 species from Northern Thailand. The Shannon–Wiener index of diversity for the observed Shorea community (2.75) was lower than that reported by Uma Shankar (2001), Pandey and Shukla (2003) and Kumar et al. (2006). While, the secondary Teak community grasped the maximum Shannon–Wiener index (3.39) and found greater than other planted Teak (2.47 to 2.68) reported by Koonkhunthod et al. (2007) in Northern Thailand.

Tree density and stand structural differences

The density of primary Shorea community (464.77 trees·ha^{-1}) was greater than rest other communities. The density of Shorea community increased due to *S. robusta*, which contributed 33.75% of total density and it is a disturbance–tolerant species (Pandey and Shukla 2001) with high regeneration ability was probably accelerated by moderate disturbance index (4.37). At ≥30 diameter class the present mean density of Shorea community (464.77 ha^{-1}) was found closed to Pandey and Shukla (1999) 451 trees·ha^{-1}; Shukla and Pandey (2000) 484 trees·ha^{-1}; Jha and Singh (1990) 294 to 559 trees·ha^{-1}; Singh et al. (1995) 180 to 860 trees·ha^{-1} and quite lower than Kumar et al. (2006) 724 to 980 trees·ha^{-1} and Pande (1999) 1150 to 1920 trees·ha^{-1}. Since, some Shorea plots were tranquilly managed under RF categories and contributed 2.96% of mature Shorea tree at 210 to >300 cm DBH. At the periphery of RF or fragmented Shorea forests disturbance occurred moderately than the least disturbed interior of RF. Hence, maximum number of trees (58.36%) were recorded at young stage (>30 to 60 cm DBH), which evident that those forests were successively conquered from past disturbances because density of smaller trees may increase after disturbance (Macedo and Anderson 1993; Bhat et al. 2000; Chittibabu and Parthasarathy 2000; Bhuyan et al. 2003). The mean stand density of primary Schima community (336.25 trees·ha^{-1}) was also comparable to different Indian moist deciduous forests and present value was lower than the stem density ha^{-1} recorded for different Indian tropical moist deciduous forest at ≥30cm diameter 407 in Eastern Ghats tropical moist deciduous forest (Reddy et al. 2008) and greater than at ≥10cm diameter 276 (Ghate et al. 1998); 352 (Sundarapandian and Swamy 1997) from Western Ghats Moist deciduous forest. The mean stem density of present Teak community was observed lower than the expected density 730 trees·ha^{-1} based on thinning practices (Koonkhunthod et al. 2007); 410 trees·ha^{-1} (Chuntanapapb 1969) and very closed to 375 trees·ha^{-1} (Chalermpongse 1992); 316.7 trees·ha^{-1} (Koonkhunthod et al. 2007) in Northern Thailand. This was also very smaller than the density (960 to 2500 trees·ha^{-1}) reported from Satpura Plaeatu in Madhya Pradesh (Pande 2001) at >1 DBH.

The mean basal area of Shorea community 26.21 m^2·ha^{-1} (range 10.59–101.68 m^2·ha^{-1}) was found comparable to 43.9 m^2·ha^{-1} (Pandey and Shukla 1999); 56.2 m^2·ha^{-1} (Shukla and Pandey 2000) and 14.5 to 71.8 m^2·ha^{-1} (Singh et al. 1995). The high basal area in some plots were recorded mainly due to occurrence of 1.85% old Shorea tree at >240 cm DBH in some mature Shorea forest towards the core of RF. On the other hand, primary Schima community represented the fragmented moist mixed deciduous forest which was mostly acquired by public and comparatively biotic pressure increased to some extend than protected Shorea forests. The mean basal area of Schima community 11.47 m^2·ha^{-1} was quite lower than 33.7 m^2·ha^{-1} reported by

Sundarapandian and Swamy (1997). As expected the mean basal area of both secondary Teak (10.76 $m^2 \cdot ha^{-1}$) and Hevea (10.57 $m^2 \cdot ha^{-1}$) communities were found comparatively lower than primary Shorea and Schima community corresponded to moderate or absence of population density at higher DBH classes. The basal area of Teak community was found very closed to Koonkhunthod et al. (2007) 9.4 $m^2 \cdot ha^{-1}$ and lower than Pande (2001) 93.93 to 155.48 $m^2 \cdot ha^{-1}$.

Population dominance and rarity

The quadratic relationship between species richness and number of individuals in the predominant group (>50 individuals) with an increasing trend was observed higher in case of primary Shorea community with 86.06% of individuals (density 400·ha^{-1}) and 25 species followed by 55% of individuals (density 367.25 trees·ha^{-1}) with 14 species in secondary Teak community (Fig. 3a); may be due to high species richness of other co–predominant species which has local adaptability in Shorea community and may be influenced by direct competition for niche. Some mid storey and under storey tree species of predominance group contributed high density due to high capacity of prolific sprouting and ramet production of fast colonizing species viz. *M. paniculata*, *H. antidysenterica*, *Antidesma* spp., *B. retusa*, *C. oblongifolius*, *M. phillippensis* etc. in Shorea community. The pattern of relationships among the common group suggested an increasing trend of common species richness with increasing density especially in Schima and Teak communities; this may be due to less competitive stresses of *T. grandis* and *S. wallichii* than *S. robusta.* While trend of rare species richness was high in case of primary Schima community as this is the largest local primary vegetation and still holds many unique species at different level of successions which may increase the process of rareness and possibly lose many species during forest maturation. Sometime loses of species could also be related to allelopathy (MacMahon and Schimpf 1981). However, the dominant and very rare groups showed significant linear relationship among the four different communities, as dominance increased as a function of stress (Keel and Prance 1979), which may have been due to past damage (Richards 1996; Burnham 2002) resulted early accumulation and regeneration of some local oligarchic tree species. Thus competition among other co–dominant and co–predominant species might enhance some species dominance and rareness especially in Teak and Shorea communities during the restoration of forest gaps by *H. antidysenterica*, *M. paniculata, B. malabarica*, *S. cerasoides*, *G. assamica*, *Antidesma* spp., *B. retusa*, *C. oblongifolius*, *M. phillippensis* etc. Overall, 17 tree species (out of 144) were recorded as very rare species with <2 individuals (out of 10957), which could be considered as singleton species and may have been attributed to their high resource extraction or low regeneration capacity within such habitat and sometime may have been coped unsuitably by predominant and dominant species of the representative communities. However, many widespread species tend to be locally abundant in certain areas and relatively rare in others (Hubbel and Foster 1983). Despite of cutting or logging for fuelwood and timber requirements, local forest dwellers were also engaged in extraction of NTFPs for edible fruits (Majumdar and Datta 2009) and ethno–medicinal usage (Majumdar et al. 2006) from a variety of trees. *Saraca asoka* (Bark) and *Entada phaseoloides* (Seed) etc. were used by the forest dependent people for wide range of ethno–medicinal formulations (Majumdar and Datta 2007). The occurrences of other single tree species may have been due to their low regeneration capacity, which may be further influenced by existing predominant species in the representative communities. Although, sometime this may also be due to species specific relations or preferred associationships among those tree communities.

Diameter classes and stand maturity

The present tree density was decreasing with increasing DBH classes, which is a typical characteristic of Tropical forest in Malaysia (Poore 1968; Ho et al. 1987), Costa Rica (Lieberman et al. 1985; Nadkarni et al. 1995), Brazilian Amazon (Swaine et al. 1987; Campbell et al. 1992), Sungei Menyala in Malaysia (Manokaran and Kochummen 1987) and Mudumalai in India (Sukumar et al. 1992). The primary Shorea community was more mature than the rest other communities and represents all DBH classes. Since, some parts of Shorea forests receiving protection under RF categories, where selective logging was relatively less in the core than the periphery of the RF. Lacking of 240–270 cm DBH class in primary Schima community and 210–300 cm in secondary Hevea community or low number of mature tree in other larger DBH classes in those tree communities suggested enough historic logging. Hence, very low abundance of mature voluminous tree and enough forest canopy gaps were resulted in those tree communities.

Disturbances

Different levels and types of disturbance have differential impacts on forest communities (Halpern and Spies 1995) and have been considered an important factor for structuring forest communities (Foster 1980; Pandey and Shukla 2003). The number of logged or dead trees in a forest could be an important indicator of such disturbance levels as observed by the absence of mature trees in the higher DBH classes. Maximum DI value was recorded for Secondary Teak community which was again supported by the presence of maximum number of young individuals (63.42%) of smallest diameter class of 30–60 cm. Because, majority of individuals within lower diameter classes resulted after selective logging (Johns 1983). Hence, development of local oligarchic small tree species were enhanced; which colonized rapidly with in the gaps of the community and concurrently an alternative non–equilibrium situation was also set up that might brought variation or change (increase) in species diversity by providing opportunity for those oligarchic tree species to establish during early or secondary formations and to modify the earlier stable community. Hence, high species diversity in present tree communities supports the intermediate disturbance hypothesis (Connell 1978).

Family Importance Value and forest characterization

Based on the FIV, four major association of predominant families could be classified for lowland moist deciduous to moist mixed deciduous forests Viz. Dipterocarpaceae, Moraceae, Euphorbiaceae, Combretaceae and Lamiaceae for Shorea community; Theaceae, Euphorbiaceae, Moraceae, Myrtaceae and Combretaceae for Schima community; Moraceae, Lamiaceae, Euphorbiaceae, Combretaceae and Apocynaceae for Teak community; Euphorbiaceae, Moraceae, Anacardiaceae, Lythraceae and Mimosaceae for Hevea community. In Neotropical deciduous forests most speciose family is Leguminosae followed by Bignoniaceae (Gentry 1995). Leguminosae is a predominant family in many Indian deciduous forest, whereas Lauraceae, Meliaceae, Combretaceae, Rubiaceae, Euphorbiaceae and Moraceae etc. elsewhere in other forest types of India (Sukumar et al. 1992; Murali et al. 1996; Uma Shankar 2001). In the present analysis Dipterocarpaceae of Shorea community stood first due to high density and basal area of *S. robusta* which increased overall FIV (79.14). Moraceae (12) and Euphorbiaceae (11) were recorded most speciose family for the present Shorea forest instead of Papilionaceae for Shorea forest in Northern India (Pandey and Shukla 2003). But the trend of high species richness of Euphorbiaceae in the present Shorea community was observed in several evergreen forests of Western Ghats (Kadavul and Parthasarathy 1999; Parthasarathy 1999; Jayakumar et al. 2009) and in the Andaman Island (Padalia et al. 2004). While, Theaceae (FIV 58.42) for primary Schima community stand first due to highest density and basal area of *S. wallichii*. Euphorbiaceae (7), Moraceae (8), Myrtaceae (4) and Combretaceae (3) were recorded as speciose families for present Schima dominant community; which found similar to several other Indian tropical moist deciduous forest, where Combretaceae, Leguminaceae, Bombacaceae, Rubiaceae and Meliaceae etc. forming the group of main predominant families (Pandey et al. 1986; Gowda 2002; Ilorkar and Khatri 2003; Padalia et al. 2004; Sen et al. 2008). Surprisingly, Moraceae (FIV 34.45) in secondary Teak community stood first instead of Lamiaceae (FIV 33.37) due to maximum species richness of Moraceae (13 species). This trend of dominance by Moraceae was also recorded similar to human–impacted tropical evergreen forest of Eastern Ghats with ten species (Chittibabu et al. 2000). Higher species richness in Moraceae was recorded for all community types due to locally availability of *A. chama, A. lakocha* and several other *Ficus* spp; their local adaptability and strong dispersal capacity might facilitate by several frugivorous birds and animals. Especially, *Trachypithecus pileatus* (Blyth 1843), capped langur, status–Vulnerable A2cd+3cd ver 3.1 (Das et al. 2008) was observed feeding on tender leaves of *Aartocarpus chama, A. lacocha, B. ceba* and *G. pinnata, F. glumerata, A. lucida* during field study in Shorea dominated community. Since, they preferred to eat 90% tree species and spent 68% of their annual feeding time eating leaves; which includes mature and young leaves, petioles of *Ficus spp, Gmelina arborea, Albizzia spp, Morus levigata,Kedia calycina, Bombax ceiba, and Sterculia villosa* etc. They are the most important preferred food resources of this species (Solanki et al. 2008a) and most of the trees were deciduous type. Most preferred tree family composition for the habitat of capped langur includes Moraceae, Mileaceae, Anacardiaceae, Euphorbiaceae, Lauraceae, Verbenaceae (Lamiaceae), Sterculaceae (Malvaceae) and Myrtacea etc. (Gupta 1998; Solanki et al. 2008a). While present habitat of capped languor was predominated by Dipterocarpaceae, Moraceae, Euphorbiaceae, Combretaceae and Lamiaceae etc. families which provided available food resources. The deciduousness and lower occurrences of evergreen or other preferred tree species (Solanki et al. 2008b) in the present habitat could be a threatening alarm for survival and breeding of this fragmented population of capped langur in absence of preferred foraging resources especially during dry seasons. Since, ca. 90% of tree species shed their leaves in Shorea dominated community during winter months. Seasonal scarcity of preferred diet items due to phenological gaps and low density of evergreen trees may cause man–langur conflicts in Shorea dominated forests. Because there exist available agriculture lands surrounding the present langur habitat which extensively using for potato and other winter crop productions. Otherwise, capped langur may be bound to alter their preferred diet choices into tender leaves, buds and fruits (ripe/unripe) of *G. pinnata*, *T. cilliata*, *L. monopetella*, *A. scholaris*, *S. personatum*, *A. acuminata*, *E. officinalis*, *H. exelsum*, *T. bellirica*, *B. retusa*, *M. paniculata* and *D. pentagyna*. etc. Since, buds, young leaves and fruits appeared in most of these trees during dry periods.

In the NMS ordination, Dipterocarpaceae (FIV 79.14) the representative of Shorea community was placed positively on both axes due to highest density and basal area of *S. robusta* and some extent accelerated by 33 tree species (out of 105) represented by five predominant families. Theaceae (FIV 58.42) representative of Schima community was placed negatively on axis–II due to relatively low species richness (23 out of 83) in five predominant families and comparatively low basal area of Schima dominated community than Shorea dominated community. On the other hand, Lamiaceae (FIV 33.37) was negatively placed on axis–I due to lower density and basal area of the five predominant families, which was positively placed on axis–II due to comparatively high species richness (35 out of 105) in the five predominant families. Euphorbiaceae (FIV 101.17) representative of secondary Hevea dominated communities was placed negatively on both axes; this may be due to comparatively low species richness (26 out of 63) and low basal area of the five predominant than rest other communities. Moraceae was negatively placed on axis–I due to lower basal area and positively on axis–II due to highest species richness as compared to other representative predominant families. High FIV of Moraceae especially in secondary Teak community may shift the secondary Teak population by native species richness of Moraceae, where Moraceae tree species may contribute maximum for both IVI and FIV to be the top predominant family over existing Lamiaceae and Euphorbiaceae species especially in case of Teak dominated community. Such competitions among the families may alter the present forest dynamics and simultaneously may increase with changing of disturbance intensity; which partially may boost up

by several seed dispersal agents during secondary forest formations. Because, species belongs to Moraceae have the advantages of attractive colored receptacle, lovability in taste, high seed production and stock, small achene, universally eaten by frugivore and high germination ability even on unsuitable habitat (tree hole, dead wood, stone and barren land).

Conclusion

Four major tree community types were identified and described for Tripura state for the first time, which will be served as baseline information for management of those lowland primary and secondary moist deciduous forests in Tripura. Tree diversity and stand structure were significantly differed along primary and secondary forest communities. The population estimation suggested several species were under threats of local extinction. The past and present level of disturbances resulted in predominance of several local oligarchic small tree species which directly changing the typical pattern of forest structure during secondary succession. The lowland primary Sal forest holds rich tree diversity which can be used for conservation of many threatened flora and fauna especially for conservation of capped langur. The secondary Teak forests also facilitated the growth and restoration of many indigenous tree species and in addition Moraceae species slowly altering the patterns of secondary Teak forests through their local availability and adaptability.

Acknowledgements
We would like to thank Sri Samir Kumar Debnath, Sri Abhijit Sarkar and Sri Monthosh Roy for their consistent supports during field survey. We are also thankful to Dr. A K Gupta, IFS, Addl. Principal Conservator of Forest, Tripura Forest Department, Govt. of Tripura for cooperation. Thanks also extended to Dr. Partha Pratim Bhattacherjee and Sri Joydeb Majumder, SRF, Department of Zoology, Tripura University for valuable suggestions. Finally we are grateful to anonymous reviewer of this paper for critical evaluation and valuable suggestions.

References

Anonymous. 1990. A study of the land system of Tripura. Unpublished report, Law Research Institute, Eastern Region, Guwahati, Assam, India.

Anonymous. 2000. A compendium of forests and forestry in Tripura. Forest Department, Govt. of Tripura, Jana Bichitra Offset, Agartala, India, pp 25–29.

Anonymous. 2009. The State of Forest Report. Forest Survey of India, Dehradun, India, pp. 151–153.

Anonymous.1956. Report of the Commissioner for Scheduled Castes and Tribes 1955–56. Government of Tripura, Agartala, India.

Ashton PS. 1964. A quantitative phytosociological technique applied to tropical mixed rain forest vegetation. *Malaysian Foreste,* **27**:304–317.

Ayyappan A, Parthasarathy N. 1999. Biodiversity inventory of trees in a large scale permanent plot of tropical evergreen forest at Varagalaiar, Anamalais, Western Ghats, India. *Biodiversity and Conservation,* **8**: 1533–1554.

Beard JS. 1955. The classification of tropical American vegetation types. *Ecology,* **36**: 89–100.

Bhat DM, Naik MB, Patagar SG, Hegde GT, Kanade YG, Hegde GN, Shastri CM, Shetti DM, Furtado RM. 2000. Forest dynamics in tropical rain forests of Uttara Kannada district in Western Ghats, India. *Current Science,* **79**: 975–985.

Bhuyan P, Khan ML, Tripathi RS. 2003. Tree diversity and population structure in undisturbed and human– impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas, India. *Biodiversity and Conservation,* **12**: 1753–1773.

Brown S, Lugo AE. 1990. Tropical secondary forests. *Journal of Ecology*, 6: 1–32.

Bullock S, Mooney H, Medina E. 1995. *Seasonally dry tropical forests*. Cambridge, UK: Cambridge University Press, p. 450.

Bunyavejchewin S. 1984. Structure and growth in teak forest 10 years after logging. *Thai Journal of Forestry,* **3 (3)**: 197–211.

Burnham RJ. 2002. Dominance, diversity and distribution on lianas in Yasuni, Ecuador: who is on top? *Journal of Tropical Ecology,* **18**: 845–864.

Campbell DG, Daly DC, Prance GT, Maciel UN. 1986. Quantitative ecological inventory of terra firme and varzea forest on the Rio Xingu, Brazilian Amazon. *Brittonia*, **38**: 369–393.

Campbell DG, Stone JL, Rosas JA. 1992. A comparison of the phytosociology and dynamics of three floodplain (varzea) forest of known ages, Rio Jurua, western Brazilian Amazon. *Botanical Journal of Linnaean Society,* **108**: 213–237.

Carnevale N, Montagnini F. 2002. Facilitating regeneration of secondary forests with the use of mixed and pure plantations of indigenous tree species. *Forest Ecology and Management,* **163**: 217–227.

Chakraborty RN. 1985. First Working Plan for Sadar Forest Division Part I, II & APP Tripura for the Year 1975–1976 to 1984–1985.

Chittibabu CV, Parthasarathy N. 2000. Attenuated tree species diversity in human–impacted tropical evergreen forest sites at Kolli hills, Eastern Ghats, India. *Biodiversity and Conservation,* **9**: 1493–1519.

Connell JH. 1978. Diversity in tropical rain forest and coral reefs. *Science,* **199**: 1302–1310.

Dansereau P. 1960. The origin and growth of plant communities. In: Zarrow M.X. (eds), *Growth in Living 435 System*: Proceedings of International Symposium on Growth, Purdue University, Indiana. New York: Basic Books, pp. 573–603.

Das J, Molur S, Bleisch W. 2008. *Trachypithecus pileatus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. Available at http://www.iucnredlist.org/. Downloaded on 12 September 2011.

Dawkins HC. 1959. The volume increment of natural tropical high–forest and limitations of improvements. *Empire Forestry Review,* **38**: 175–180.

Deb DB. 198 – 1983. *The Flora of Tripura State*. Vols.I–II. New Delhi: Today and Tomorrow's Printers and Publishers,.

Denslow JS. 1980. Patterns of species diversity during succession under different disturbance regimes. *Oecologia,* **46**: 18–21.

Foster RB. 1980. Heterogeneity and disturbance in tropical vegetation. In: Soule ME, Wilox BA (eds), *Conservation biology: An evolutionary ecological perspective*. Sunderland (MS): Sinauer Associates. pp 75–92.

Ganesh T, Ganesan R, Soubadradevy M, Davidar P, Bawa KS. 1996. Assessment of plant biodiversity at a mid–elevation evergreen forest of Kalakad Mundanthurai Tiger reserve, Western ghats, India. *Current Science,* **71**: 379–392.

Gentry AH. 1995. Diversity and floristic composition of Neotropical dry forests. In: Bullock SH, Mooney HA, Medina E (eds). *Seasonally dry tropical forests*. Cambridge: Cambridge University Press, pp 146–194.

Ghate U, Joshi NV, Gadgil M. 1998. On the patterns of tree diversity in the Western Ghats of India. *Current Science,* **75**: 594–603.

Goldammer JG. 1993. *Feuer in Waldökosystemen der Tropen und Subtropen*. Basel–Boston: Birkhäuser–Verlag, p.251.

Gowda R. 2002. Working Plan of Mangalore Forest Division (2002–03 to 2011–12), Working Plan & Survey, Chikmagalur, Government of Karna-

taka, India.

Gupta AK. 1998. Habitat use by capped langur (*Trachypithecus pileatus*) in Tripura, northeast India. (abstract) XVII Congress of the International Primatological Society. University of Antananarivo, Madagascar.

Gupta AK. 2000. Shifting cultivation and conservation of biological diversity in Tripura, Northeast India. *Human Ecology,* **28**(4): 605–629.

Halpern CB, Spies TA. 1995. Plant species diversity in natural and managed forests of the Pacific Northwest. *Ecological Application,* **5**: 913–934.

Hammer O, Harper DAT, Ryan PD. 2001. PAST: Paleontological Statistics Software Package for education and data analysis, Version 2.03. Paleontologia Electronica, **4**(1): 9 pp. (http://folk.uio.no/ohammer/past).

Holdridge LR. 1967. Life Zone Ecology. San Jose: Tropical Science Centre, San Joes, Costa Rica.

Hubbell SP, Foster RB. 1983. Diversity of canopy trees in a neotropical forest and implication for conservation. In: Sutton SL, Whitmore TC, Chadwick AC (eds). *The Tropical Rain Forest*: *Ecology and Management*, Oxford: Blackwell, pp 25–41.

Ilorkar VM, Khatri PK. 2003. Phytosociological study of Navegaon National Park (Maharashtra). *Indian Forester,* **129**: 377–387.

ITTO. 2002. ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. ITTO Policy Development Series No. 13

Janzen DH. 1986. Tropical dry forests: the most endangered major tropical ecosystem. In: Wilsin E.O. (eds), *Biodiversity*. Washington: National Academy Press, pp 130–137.

Jayakumar S, Ramachandran A, Heo J. 2009. Comparison of floristic diversity of evergreen forest inferred from different sampling approaches in the Eastern Ghats of Tamil Nadu, India. *Current Science,* **96**(4): 575–581.

Jha CS, Singh JS. 1990. Composition and dynamics of dry tropical forest in relation to soil texture. *Journal of Vegetation Science,* **1**: 609–614.

Johns AD. 1983. *Ecological effects of selective logging in a West Malaysian Rainforest*. PhD. Thesis, University of Cambridge, U.K.

Kadavul K, Parthasarathy N.1999. Plant biodiversity and conservation Eastern Ghats, India. *Biodiversity and Conservation,* **8**:421–439.

Kaewkrom P, Gajaseni J, Jordan CF, Gajaseni N. 2005. Floristic regeneration in five types of teak plantations in Thailand. *Forest Ecology and Management,* **210**: 351–361.

Kanjilal UN, Kanjilal PC, Das A, De RN, Bor NL. 1934 – 1940. *Flora of Assam*. Vols.1–5. Government Press, Shillong.

Kashian DM, Barnes BV, Walker WS. 2003. Ecological species groups of landform level ecosystems dominated by jack pine in northern Lower Michigan, USA. *Plant Ecology,* **166**(1): 75–91.

Keel SHK, Prance GT. 1979. Studies of the vegetation of a white–sand black–water igapo (Rio Negro, Brazil). *Acta Amazonica,* **9**: 645–655.

Koonkhunthod N, Sakurai K, Tanaka S. 2007. Composition and diversity of woody regeneration in a 37–year–old teak (*Tectona grandis* L.) plantation in Northern Thailand. *Forest Ecology and Management,* **247**: 246–254.

Kumar A, Marcot BG, Saxena A. 2006. Tree species diversity and distribution patterns in tropical forests of Garo Hills. *Current Science,* **91**(10): 1370–1381.

Lieberman D, Lieberman M, Hartshorn G, Peralta R. 1985. Growth rates and age–size relationships of tropical wet forest trees in Costa Rica. *Journal of Tropical Ecolog,* **1**: 97–109.

Lugo AE. 1997. The apparent paradox of reestablishing species richness on degraded lands with tree monocultures. *Forest Ecology and Management,* **99**: 9–19.

Macedo DS, Anderson AB. 1993. Early ecological changes associated with logging in an Amazon floodplain. *Biotropica,* **25**: 151–163.

MacMahon JA, Schimpf DJ. 1981. Water as a factor in the biology of North American desert plains. In: Evans DD, Thames JL (eds). Water in Desert Ecosystems. US/IBP synthesis series, Stroudsburg. pp 114 –171.

Majumdar K, Datta BK. 2007. A study on ethno–medicinal usage of plants among the folklore herbalists and Tripuri medical practitioners: Part–II, *Natural Product Radiance,* **6**: 66–73.

Majumdar K, Datta BK. 2009. Traditional wild edible fruits for the forest dwellers of Tripura, India. *Pleione,* **3**(2): 167–178.

Majumdar K, Saha R, Datta BK. 2006. Medicinal Plants Prescribe by Different Tribal and Non–tribal Medicine Men of Tripura State, *Indian Journal of Traditional Knowledge,* **5**(4): 559–562.

Manokaran N, Kochummen KM. 1987. Recruitment, growth and mortality of tree species in a lowland dipterocarp forest in Peninsular Malaysia. *Journal of Tropical Ecology,* **3**: 315–330.

Menhinick EF. 1964. A comparison of some species–individuals diversity indices applied to samples of field insects. *Ecology,* **45**: 859–861.

Mishra R. 1968. *Ecology Workbook*, Oxford & IBH Co., New Delhi, 244 pp.

Muller–Dombois D, Ellenberg H. 1974. *Aims and methods of vegetation ecology*, John Wiley and sons, Inc.

Murali KS, Uma Shankar, Uma Shaanker R, Ganeshaiah KN, Bawa, KS. 1996. Extraction of non–timber forest products in the forest of Biligiri Rangan hills, India. 2. Impact of NTFP extraction on regeneration, population structure and species composition. *Economic Botany,* **50**: 252–269.

Murphy PG, Lugo AG. 1986. *Ecology of tropical dry forest*. *Annual Review of Ecology and Systematics*, **17**: 67–88.

Myers N, Russell A, Mittermelert C, Mittermelert G, Gustavo AB, Fonseca da, Jennifer K. 2000. Biodiversity hotspots for conservation priorities. *Nature,* **24**: 853–858.

Nadkarni NM, Matelson TJ, Haber WA. 1995. Structural characteristics and floristic composition of a neotropical cloud forest, Monteverde, Costa Rica. *Journal of Tropical Ecology,* **11**: 481–495.

Neeranathpibul J, Sangtongpraow S. 2002. Plant species diversity and soil property changes in different–year old teak plots of Maehad plantation, Nongmuangkhai District, Phrae Province. *Thai Journal of Forestry,* **19–21**: 136–145 (in Thai).

Padalia H, Chauhan N, Porwal MC, Roy PS. 2004. Phytosociological observations on trees species diversity of Andaman Islands, India. *Current Science,* **87**: 799–806.

Pande PK. 1999. Comparative vegetation analysis and sal (*Shorea robusta*) regeneration in relation to their disturbance magnitude in some sal forests. *Tropical Ecology,* **40**: 51–61.

Pande PK. 2001. Structure of tropical dry deciduous teak forest of Satpura Plateau (India) with special emphasis on regeneration and disturbances. *Journal of Tropical Forest Science,* **13**: 329–343.

Pandey CN, Ladwa YR, Joshi RR. 1986. Working Plan of Dadra and Nagar Haveli Forest Division (1986–87 to 1995–96).

Pandey SK, Shukla RP. 1999. Plant diversity and community patterns along the disturbance gradient in plantation forests of sal (*Shorea robusta* Gaertn). *Current Science,* **77**: 814–818.

Pandey SK, Shukla RP. 2001. Regeneration strategy and plant diversity status in degraded sal forests. *Current Science,* **81**: 95–102.

Pandey SK, Shukla RP. 2003. Plant diversity in managed sal (*Shorea robusta* Gaertn. f) forest of Gorakhpur, India: species composition, regeneration and conservation. *Biodiversity and Conservation,* **12**: 2295–2319.

Parrotta J, Turnbull J, Jones N. 1997. Catalyzing native forest regeneration on degraded tropical lands. *Forest Ecology and Management*, **99**: 1–7.

Parthasarathy N. 1999. Tree diversity and distribution in undisturbed and human–impacted sites of tropical wet evergreen forest in southern Western Ghats, India. *Biodiversity and Conservation,* **8**: 1365–1381.

Pielou EC. 1966. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, **13**: 131–144.

Poore MED. 1968. Studies in Malaysian rainforest 1. The forest on Triassic sediments in Jengka forest reserve. *Journal of Ecology,* **56**: 143–196.

Powers JS, Haggar JP, Fisher RF. 1997. The effect of overstory composition on understory woody regeneration and species richness in seven year old plantations in Costa Rica. *Forest Ecology and Management,* **99**: 43–54.

Rao P, Barik SK, Pandey HN, Tripathi RS. 1990. Community composition and tree population in a subtropical broad–leaved forest along a disturbance gradient. *Vegetatio*, **88**: 151–162.

Reddy CS, Shilpa B, Giriraj A, Reddy KN, Rao KT. 2008. Structure and floristic composition of tree diversity in tropical dry deciduous forest of Eastern Ghats, Southern Andhra Pradesh, India. *Asian Journal of Scientific Research,* **1**: 57–64.

Richards PW. 1955. The secondary succession in the tropical rain forest. *Science Progress*, **43**(169): 45–57.

Richards PW. 1996. *The Tropical Rain Forest*, 2nd Edn. Cambridge: Cambridge University Press. p.87.

Rundel PW, Boonpragob K. 1995. Dry forest ecosytrees of Thailand. In: Bullock S, Mooney H, Medina E (eds), *Seasonally dry tropical forests*. Cambridge University Press. Pp. 93–123.

Saha S. 2001. Vegetation composition and structure of *Tectona grandis* (teak family Verbenaceae) plantations and dry deciduous forests in central India. *Forest Ecology and Management,* **148**: 159–167.

Sapkota IP, Tigabu M, Oden PC. 2009. Species diversity and regeneration of old–growth seasonally dry *Shorea robusta* forests following gap formation. *Journal of Forestry Research*, **20**: 7–14.

Sen A, Johri T, Bisht NS. 2008. Analysis of the effects of anthropogenic interferences on tree species composition in the forests of Dadra and Nagar Haveli, India. *Current Science,* **95**(1): 50–58.

Shannon CE, Wiener W. 1963. *The mathematical theory of communities*. University of Illinois press, Urbana. Pp. 111-117.

Shukla RP, Pandey SK. 2000. Plant diversity and community features of the forested landscape adjacent to foot–hills of Central Himalyas. In: Tiwari SC, Dabral PP (eds), *Natural Resources, Conservation and Management for Mountain Development*. Dehradun: International Book Distributor, pp. 15–37.

Simpson EM. 1949. Measurement of diversity. *Nature,* **16**3: 688.

Singh A, Reddy VS, Singh JS. 1995. Analysis of woody vegetation of Corbett National Park, India. *Vegetatio,* **120**: 69–79.

Sips P. 1993. *Management of tropical secondary rain forests in Latin America*. Wageningen: Stiching Bos, 71 pp.

Solanki GS, Kumar A, Sharma BK. 2008a. Feeding Ecology of *Trachypithecus pileatus* in India. *International Journal of Primatology*, **29**: 173–182.

Solanki GS, Kumar A, Sharma BK. 2008b. Winter food selection and diet composition of capped langur (*Trachypithecus pileatus*) in Arunachal Pradesh, India. *Tropical Ecology*, **49**(2): 157–166.

Sukumar R, Dattaraja HS, Suresh HS, Radhakrishnan J, Vasudev R, Nirmala S, Joshi NV. 1992. Long–term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. *Current Scienc,* **62**: 608–616.

Sundarapandian SM, Swamy PS. 1997. Plant biodiversity at Lowelevation Evergreen and Moist Deciduous Forests at Kodayar in the Western Ghats. *International Journal of Ecology and Environmental Science,* **23**: 363–379.

Swaine MD, Lieberman D, Putz FE. 1987. The dynamics of tree populations in tropical forest: a review. *Journal of Tropical Ecology,* **3**: 359–366.

Uma Shankar. 2001. A case of high tree diversity in a sal (*Shorea robusta*)–dominated lowland forest of Eastern Himalaya: floristic composition, regeneration and conservation. *Current Science,* **81**: 776–786.

Whitemore TC. 1993. *An Introduction to Tropical rain forest*, Oxford: Oxford University Press, p.226.

Appendix I. Density, basal area, important value index (IVI) of the tree species in four different tree communities of Tripura.

Tree Community Association		Primary Forest						Secondary Forest					
		Sal dominated			Schima dominated			Teak dominated			Havea dominated		
Species	Family	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI
Acronychia pedunculata (L.) Miq.	Rutaceae	0.54	0.08	0.50	0.50	*	0.62	-	-	-	-	-	-
Aegle marmelos (L.) Correa	Rutaceae	0.23	0.01	3.99	0.50	0.01	0.47	1.25	0.07	1.80	0.67	0.02	1.30
Aglaia spectabilis Miq.	Meliaceae	0.08	*	3.23	-	-	-	-	-	-	-	-	-
Alangium chinensis (Lour.) Rehder	Alangiaceae	-	-	-	-	-	-	0.50	0.02	0.48	-	-	-
Alangium salvifolium (L.f.) Wang	Alangiaceae	-	-	-	-	-	-	0.63	0.01	0.61	-	-	-
Albizia chinensis (Osbeck) Merr	Mimosaceae	1.08	0.05	2.92	3.50	0.55	7.33	4.00	0.22	4.83	6.67	0.26	6.89
Albizia lebbeck (L.) Benth.	Mimosaceae	0.23	0.02	2.68	3.50	0.10	2.31	2.50	0.18	3.40	2.00	0.06	3.01
Albizia procera (Roxb.) Benth.	Mimosaceae	3.62	0.23	2.42	2.25	0.13	3.50	6.00	0.36	6.97	1.67	0.09	3.55
Alstonia scholaris (L.) R. Br.	Apocynaceae	0.46	0.01	1.62	2.00	0.11	3.07	0.75	0.02	0.81	1.67	0.02	2.52
Ampelocissus barbata (Wall.) Planch.	Vitaceae	0.38	*	0.48	-	-	-	-	-	-	1.00	0.04	1.99
Anacardium occidentale L.	Anacardiaceae	-	-	-	-	-	-	-	-	-	-	-	-
Anogeissus acuminata Wall.	Combretaceae	6.38	1.15	10.49	1.75	0.45	4.89	4.13	0.79	9.61	-	-	-
Anthocephalus chinensis (Lamk.) A. Rich	Rubiaceae	0.23	0.01	2.00	-	-	-	-	-		0.33	0.01	0.62
Antidesma bunius (L.) Spreng.	Euphorbiaceae	0.31	*	3.28	-	-	-	-	-		-	-	-
Aphanamixis polystachya (Wall.) Parker	Meliaceae	0.77	0.02	1.83	1.50	0.04	1.69	2.63	0.06	2.12	-	-	-
Aquilaria malaccensis Lamk.	Thymelaeaceae	-	-	-	-	-	-	0.25	*	0.21	-	-	-
Archiodendron sp.	Mimosaceae	-	-	-	0.50	*	0.61	-	-	-	-	-	-
Artocarpus chama Buch.-Ham. ex Wall	Moraceae	23.85	3.44	18.65	7.00	0.39	7.89	7.63	0.54	9.80	12.67	0.83	15.59
Artocarpus heterophyllus Lamk.	Moraceae	0.08	*	0.60	2.75	0.21	3.94	4.63	0.35	6.11	3.00	0.26	6.06
Artocarpus lakoocha Roxb.	Moraceae	0.23	0.01	1.61	-	-	-	0.38	0.01	0.41	1.00	0.08	1.95
Azadirachta indica A. Juss.	Meliaceae	-	-	-	-	-	-	0.13	*	0.15	-	-	-
Bauhinia malabarica Roxb.	Caesalpiniaceae	1.62	0.04	0.56	21.00	0.55	14.66	7.50	0.22	6.66	4.33	0.07	3.82
Bischofia javanica BI.	Euphorbiaceae	-	-	-	-	-	-	0.25	0.01	0.35	-	-	-
Bombax ceiba L.	Bombacaceae	1.23	0.19	8.68	0.25	*	0.33	1.00	0.07	1.61	1.00	0.02	1.80
Brassaiopsis glomerulata (BI.) Regel.	Araliaceae	-	-	-	0.25	*	0.31	-	-	-	-	-	-
Brassaiopsis griffithii C. B. Clarke.	Araliaceae	0.15	*	5.93	-	-	-	0.50	*	0.56	-	-	-
Bridelia assamica Hook. *f.*	Euphorbiaceae	-	-	-	-	-	-	0.13	0.00	0.14	-	-	-
Bridelia pubescens Kurz	Euphorbiaceae	-	-	-	-	-	-	-	-	-	0.67	0.01	0.71

Continued to Appendix I

Tree Community Association		Primary Forest						Secondary Forest					
		Sal dominated			Schima dominated			Teak dominated			Havea dominated		
Species	Family	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI
Bridelia retusa (L.) Spreng.	Euphorbiaceae	1.38	0.05	1.77	3.00	0.06	3.10	5.00	0.11	3.99	1.00	0.01	1.74
Butea parviflora Roxb.	Papilionaceae	-	-	-	-	-	-	0.50	0.01	0.49	-	-	-
Callicarpa arborea Roxb.	Lamiaceae	3.23	0.08	4.40	2.75	0.06	2.84	5.13	0.09	4.26	3.33	0.07	3.49
Canthium glabrum BI.	Rubiaceae	-	-	-	-	-	-	0.13	*	0.14	-	-	-
Careya arborea Roxb.	Lecythidaceae	25.92	1.09	10.49	13.75	0.45	12.72	7.25	0.27	7.09	11.00	0.23	7.58
Cassia fistula L.	Caesalpiniaceae	10.15	0.28	3.38	4.00	0.07	3.33	6.13	0.15	5.48	2.67	0.12	3.79
Cassia renigera Wall. ex Benth.	Caesalpiniaceae	0.15	*	2.54	-	-	-	-	-	-	-	-	-
Cassia siamea Lamk.	Caesalpiniaceae	4.00	0.16	1.66	-	-	-	3.75	0.14	3.16	-	-	-
Castanopsis armata D. Don	Fagaceae	1.00	0.11	3.40	-	-	-	-	-	-	-	-	-
Castanopsis indica A. DC.	Fagaceae	-	-	-	1.00	0.05	0.95	-	-	-	-	-	-
Chaetocarpus castanicarpus (Roxb.) Thw.	Euphorbiaceae	5.62	0.10	2.61	-	-	-	0.50	0.01	0.53	-	-	-
Cinnamomum obtusifolium Nees.	Lauraceae	0.08	*	1.43	-	-	-	-	-	-	-	-	-
Cordia dichotoma Forst. *f.*	Ehretiaceae	-	-	-	0.25	*	0.31	0.63	0.03	0.68	-	-	-
Cordia grandis Roxb.	Ehretiaceae	0.23	0.01	1.06	0.50	0.01	0.63	0.63	0.03	0.90	-	-	-
Croton oblongifolius Roxb.	Euphorbiaceae	0.69	0.02	0.73	4.75	0.10	3.96	1.00	0.03	1.06	2.67	0.06	3.61
Crypteronia glabra Endl.	Lythraceae	0.08	*	0.53	-	-	-	0.13	0.00	0.17	0.67	0.01	0.72
Dalbergia lanceolaria L. *f.*	Papilionaceae	0.54	0.01	0.30	-	-	-	-	-		-	-	-
Dalbergia stipulacea Roxb.	Papilionaceae	-	-	-	-	-	-	0.13	*	0.14	-	-	-
Dalbergia thomsonii Benth.	Papilionaceae	-	-	-	-	-	-	0.50	0.02	0.44	-	-	-
Dalbergia volubilis Roxb.	Papilionaceae	0.38	*	0.23	-	-	-	0.13	*	0.14	0.33	*	0.58
*Derris robusta (*Roxb.) Benth.	Papilionaceae	2.85	0.14	1.52	3.00	0.06	1.84	2.63	0.08	2.82	0.33	0.01	0.67
*Desmos longiflorus (*Roxb.) Safford.	Annonaceae	0.08	*	0.79	-	-	-	-	-	-	-	-	-
Dillenia pentagyna Roxb.	Dilleniaceae	4.77	0.21	1.88	3.50	0.09	3.58	1.50	0.12	2.12	-	-	-
Diospyros peregrina Guerke.	Ebenaceae	-	-	-	-	-	-	0.63	0.01	0.47	-	-	-
Dipterocarpus turbinatus Gaertn.	Dipterocarpaceae	11.62	1.08	6.76	0.25	*	0.31	0.63	0.02	0.70	0.67	0.01	0.74
*Duabanga grandiflora (*Roxb. ex DC.) Walp.	Sonneratiaceae	-	-	-	-	-	-	0.63	0.02	0.65	0.67	0.04	1.49
Dysoxylum procerum Hiern.	Meliaceae	0.08	*	0.08	-	-	-	-	-	-	-	-	-
Elaeocarpus floribundus BI.	Elaeocarpaceae	-	-	-	0.50	0.04	0.68	-	-	-	-	-	-
Elaeocarpus robustus BI.	Elaeocarpaceae	0.23	0.07	0.37	0.50	0.01	0.66	-	-	-	-	-	-
Elaeocarpus sp.	Elaeocarpaceae	-	-	-	-	-	-	0.13	*	0.15	1.33	0.01	1.43
Emblica officinalis Gaertn.	Euphorbiaceae	5.15	0.07	1.65	3.50	0.04	3.50	1.25	0.01	1.15	0.67	0.01	0.71
Engelhardia spicata Lechen ex BI.	Junglandaceae	-	-	-	1.00	0.03	1.24	-	-	-	-	-	-
Entada phaseoloides (L.) Merr.	Mimosaceae	0.08	*	0.08	-	-	-	-	-	-	-	-	-
Erioglossum rubiginosum (Roxb.) BI.	Sapindaceae	0.08	0.01	0.13	-	-	-	0.13	0.00	0.14	1.00	0.01	1.72
Erythrina arborescens Roxb.	Papilionaceae	0.08	0.01	0.12	-	-	-	2.25	0.07	1.79	1.33	0.08	2.08
Eugenia macrocarpa Roxb.	Myrtaceae	1.85	0.63	3.12	0.50	0.01	0.67	-	-		-	-	-
Eugenia praecox Roxb.	Myrtaceae	0.15	0.01	2.19	-	-	-	-	-		-	-	-
Ficus auriculata Lour.	Moraceae	0.15	0.00	3.24	0.25	0.02	0.42	2.13	0.05	1.72	0.67	0.02	0.83
Ficus benghalensis L.	Moraceae	-	-	-	0.50	0.01	0.69	-	-		-	-	-
Ficus benjamina L.	Moraceae	-	-	-	-	-	-	0.50	0.03	0.51	-	-	-
Ficus fistulosa Reinw. ex Blume	Moraceae	-	-		-	-	-	-	-	-	0.33	0.01	0.62
Ficus hirta Vahl.	Moraceae	0.08	0.00	1.88	-	-	-	-	-	-	-	-	-
Ficus hispida L.*f.*	Moraceae	3.23	0.05	2.02	4.75	0.10	4.90	7.00	0.19	5.80	2.00	0.02	1.74
Ficus lepidosa Wall.	Moraceae	-	-	-	-	-	-	1.63	0.03	1.29	-	-	-
Ficus nervosa Heyne. ex Roth.	Moraceae	0.31	*	1.17	0.25	0.03	0.56	1.13	0.03	1.03	-	-	-
Ficus racemosa L.	Moraceae	0.38	0.01	0.18	0.75	0.04	0.97	0.38	*	0.43	2.00	0.07	3.06
Ficus religiosa L.	Moraceae	0.38	0.24	2.87	-	-	-	0.13	0.07	0.76	-	-	-
Ficus semicordata Buch-Ham. ex Smith	Moraceae	0.69	0.02	1.68	0.50	0.02	0.79	1.75	0.03	1.72	0.33	0.01	0.66
Ficus virens Ait.	Moraceae	0.62	0.16	2.14	-	-	-	0.25	0.02	0.37	-	-	-
Firmiana colorata (Roxb.) R.Br.	Sterculiaceae	2.23	0.03	1.56	1.50	0.03	1.75	3.88	0.07	3.32	0.33	0.01	0.61
Flacourtia jangomas (Lour.) Raeusch.	Flacourtiaceae	-	-	-	-	-	-	0.13	*	0.14	-	-	-
Garcinia cowa Roxb. ex DC.	Guttiferae	3.46	0.11	4.22	0.75	0.01	0.99	2.13	0.03	1.93	-	-	-
Gardenia resinifera Roth	Rubiaceae	0.38	0.02	0.54	2.75	0.10	2.80	0.13	*	0.15	-	-	-
Garuga pinnata Roxb.	Burseraceae	4.15	0.09	2.91	1.50	0.03	1.56	1.50	0.03	1.57	0.67	0.01	1.15
Glochidion assamicum Hook. *f.*	Euphorbiaceae	6.15	0.11	2.11	9.25	0.10	7.31	5.13	0.09	3.75	0.67	0.05	1.54
Gmelina arborea L.	Lamiaceae	1.77	0.13	0.95	-	-	-	4.75	0.16	4.10	-	-	-
Grewia hirsuta Vahl	Tiliaceae	0.23	*	0.38	1.00	0.01	0.61	1.00	0.02	0.88	-	-	-
Grewia viminea Wall. ex Burret.	Tiliaceae	0.08	*	0.28	-	-	-	0.75	0.01	0.66	-	-	-

Continued to Appendix I

Tree Community Association		Primary Forest						Secondary Forest					
		Sal dominated			Schima dominated			Teak dominated			Havea dominated		
Species	Family	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI	DEN	BA	IVI
Heteropanax fragrans Seem.	Araliaceae	-	-	-	-	-	-	1.88	0.04	1.88	-	-	-
Hevea brasiliensis Muell.-Arg.	Euphorbiaceae	-	-	-	-	-	-	-	-	-	110.33	4.75	88.71
Holarrhena antidysenterica G. Don. ex DC.	Apocynaceae	9.92	0.17	2.90	13.75	0.21	8.91	30.63	0.52	18.17	14.33	0.20	10.55
Hymenodictyon excelsum (Roxb.)Wall.	Rubiaceae	1.23	0.02	2.33	0.75	0.01	0.99	2.00	0.04	1.90	0.33	*	0.58
Indigofera atropurpurea F.-Ham.	Papilionaceae	-	-	-	-	-	-	0.25	*	0.19	-	-	-
Kurrimia pulcherrima Wall.	Celastraceae	-	-	-	0.50	0.10	1.23	-	-	-	-	-	-
Lagerstroemia parviflora Roxb.	Lythraceae	11.77	0.21	4.43	10.25	0.19	7.94	12.38	0.50	11.51	17.67	0.46	13.76
Lagerstroemia speciosa (L.) Pers.	Lythraceae	0.08	*	0.40	1.50	0.02	1.22	-	-	-	-	-	-
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	7.69	0.58	4.12	13.25	0.34	11.03	16.25	0.66	15.87	14.67	0.44	14.67
Lithocarpus spicata (Smith) Rehd.	Fagaceae	0.38	0.01	0.39	-	-	-	-	-	-	-	-	-
Litsea glutinosa (Lour.) C. B. Robinson	Lauraceae	2.46	0.04	1.39	3.25	0.06	3.20	8.38	0.15	6.48	5.67	0.09	5.76
Litsea monopetalla (Roxb.) Pers.	Lauraceae	0.23	0.01	0.73	-	-	-	2.25	0.10	2.53	0.67	0.01	1.16
Macaranga denticulata (BI.) Muell.-Arg.	Euphorbiaceae	1.08	0.02	0.82	5.25	0.11	4.42	2.63	0.08	2.46	4.67	0.08	4.52
Macaranga peltada (Roxb.) Mueller.	Euphorbiaceae	0.38	0.01	0.49	-	-	-	0.50	0.01	0.48	-	-	-
Macropanax undulatus (Wall. ex G. Don) Seem.	Araliaceae	-	-	-	1.00	0.01	1.02	-	-	-	-	-	-
Maesa ramentacea (Roxb.) A. DC.	Myrsinaceae	0.92	0.01	2.42	0.75	0.01	0.93	1.13	0.03	1.07	-	-	-
Mallotus philippensis (Lamk.) Muell.-Arg.	Euphorbiaceae	2.00	0.04	1.87	1.00	0.01	1.07	8.63	0.15	6.54	2.67	0.04	3.01
Mangifera indica L.	Anacardiaceae	-	-	-	0.75	0.05	1.34	0.13	0.01	0.20	0.33	0.07	1.17
Markhamia stipulata (Wall.) Seem.	Bignoniaceae	3.15	0.12	1.60	2.25	0.12	2.99	3.63	0.06	3.22	-	-	-
Meyna spinosa Roxb.	Rubiaceae	0.38	*	0.16	1.75	0.03	1.47	0.88	0.03	1.08	0.33	*	0.57
Michelia sp.	Magnoliaceae	0.31	0.08	0.42	-	-	-	-	-	-	-	-	-
Microcos paniculata L.	Tiliaceae	9.08	0.15	2.84	7.75	0.15	6.15	11.38	0.17	7.84	9.33	0.13	7.80
Micromellum intergifolium (F.-Ham. ex DC.) Wight & Arn.	Rutaceae	-	-	-	0.50	0.00	0.61	-	-	-	-	-	-
Mitragyna rotundifolia (Roxb.) O. Ktze	Rubiaceae	6.38	0.30	2.76	4.25	0.06	3.12	6.63	0.10	5.55	2.33	0.05	3.82
Oroxylum indicum (L.) Vent.	Bignoniaceae	1.92	0.05	1.23	1.75	0.03	1.83	4.00	0.08	3.47	2.00	0.03	2.27
Parkia roxburghii G. Don.	Mimosaceae	-	-	-	-	-	-	0.25	0.01	0.33	-	-	-
Pterospermum acerifolium Willd.	Sterculiaceae	0.15	*	0.23	1.75	0.03	1.88	1.00	0.02	0.94	3.00	0.13	4.39
Pterospermum semisagittatum F.-Ham. ex Roxb.	Sterculiaceae	1.77	0.05	0.76	0.25	*	0.32	2.38	0.08	2.01	0.33	*	0.57
Sapium baccatum Roxb.	Euphorbiaceae	0.15	0.02	0.55	-	-	-	-	-	-	-	-	-
Saraca asoca (Roxb.) de Wilde.	Caesalpiniaceae	0.08	*	0.15	-	-	-	-	-	-	-	-	-
Saurauia roxburghii Wall.	Saurauiaceae	0.38	0.07	0.49	-	-	-	-	-	-	-	-	-
Schima wallichii (DC.) Korth.	Theaceae	20.31	1.30	9.44	85.25	3.65	64.30	0.75	0.03	0.98	9.67	0.32	7.55
Semecarpus anacardium L.*f.*	Anacardiaceae	0.08	*	0.16	0.50	0.01	0.49	-	-	-	-	-	-
Shorea robusta Gaertn.	Dipterocarpaceae	156.85	9.66	70.67	3.00	0.13	2.23	1.50	0.04	1.39	-	-	-
Spondias pinnata (L. f.) Kurz	Anacardiaceae	0.23	0.01	0.14	0.50	0.02	0.72	0.13	*	0.16	0.67	0.05	1.56
Sterculia villosa Roxb. ex Masters	Sterculiaceae	2.92	0.04	0.93	1.75	0.05	1.41	3.50	0.10	3.25	1.67	0.02	1.65
Stereospermum personatum (Hassk.) Chatterjii	Bignoniaceae	2.23	0.16	1.65	1.25	0.03	1.29	2.25	0.08	2.29	-	-	-
Streblus asper Lour.	Moraceae	0.62	0.01	0.32	-	-	-	5.25	0.08	3.85	2.00	0.02	2.18
Suregada multiflora (A. Juss.) Baill.	Euphorbiaceae	3.85	0.06	1.12	5.75	0.08	4.13	3.88	0.06	3.21	-	-	-
Symplocos ferruginea Roxb.	Symplocaceae	0.15	*	0.55	-	-	-	-	-	-	-	-	-
Syzygium cerasoides (Roxb.) Chatt.	Myrtaceae	6.08	0.23	2.32	10.00	0.18	8.24	4.00	0.17	4.75	4.67	0.37	8.51
Syzygium cumini (L.) Skeels	Myrtaceae	6.54	0.51	3.43	2.50	0.76	8.63	6.63	0.28	7.11	4.00	0.13	5.14
Syzygium fruticosum DC.	Myrtaceae	0.23	*	0.13	5.75	0.07	3.60	0.13	*	0.17	-	-	-
Syzygium jambos (L.) Alston	Myrtaceae	0.08	*	0.09	-	-	-	-	-	-	-	-	-
Tamarindus indica L.	Caesalpiniaceae	-	-	-	-	-	-	0.38	0.02	0.60	-	-	-
Tectona grandis L.*f.*	Lamiaceae	18.77	0.46	8.17	-	-	-	37.00	1.17	26.44	4.67	0.16	4.36
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	23.85	1.03	9.31	16.25	0.44	11.64	16.38	0.50	13.64	8.00	0.25	8.53
Terminalia chebula Retz.	Combretaceae	0.23	0.04	0.27	1.00	0.03	1.38	0.13	*	0.14	-	-	-
Toona ciliata M. Roem.	Meliaceae	-	-	-	1.00	0.02	1.15	0.63	0.02	0.72	1.00	0.02	0.99
Trema orientalis (L.) BI.	Ulmaceae	0.69	0.02	0.36	1.25	0.02	1.61	4.00	0.20	4.62	1.00	0.10	2.20
Trewia nudiflora L.	Euphorbiaceae	-	-	-	-	-	-	0.13	*	0.14	-	-	-
Vitex altisima L.*f.*	Lamiaceae	-	-	-	1.75	0.03	1.46	-	-	-	-	-	-
Vitex peduncularis Wall ex Scauer.	Lamiaceae	6.92	0.23	2.43	6.50	0.17	5.77	2.88	0.04	2.29	1.33	0.02	1.93
Vitex pubescens Vahl.	Lamiaceae	1.00	0.02	0.36	0.50	0.02	0.56	0.25	*	0.19	-	-	-
Xantolis assamica (C.B. Clarke.) van Royen	Sapotaceae	0.69	0.01	0.24	-	-	-	0.38	*	0.34	-	-	-
Zanthoxylum limonella (Dennst.) Alston	Rutaceae	0.08	*	0.34	1.00	0.02	1.07	0.75	0.02	0.87	-	-	-
Ziziphus rugosa Lamk.	Rhamnaceae	4.23	0.06	1.32	4.50	0.05	3.09	5.13	0.06	3.20	1.00	0.01	1.72
Ziziphus xylopyra Willd.	Rhamnaceae	-	-	-	0.25	*	0.31	0.50	0.01	0.52	-	-	-
Total		**464.77**	**26.21**	**300**	**336.25**	**11.47**	**300**	**333.88**	**10.76**	**300**	**299.67**	**10.57**	**300**

*BA value <0.01

Appendix II. Family–wise tree species richness, density, basal area and family important value (FIV) in four different tree communities of Tripura.

Family	Primary Forest community								Secondary Forest community								NMS Ordination	
	Sal dominated				Schima dominated				Teak dominated				Havea dominated					
	SP	DEN	BA	FIV	SP	DEN	BA	FIV	SP	DEN	BA	FIV	SP	DEN	BA	FIV	Axis -1	Axis-2
Alangiaceae	-	-	-	-	-	-	-	-	2	1.125	0.02	2.44	-	-	-	-	0.08	-0.01
Anacardiaceae	3	8.00	0.59	6.83	4	15	0.43	13.08	3	16.5	0.67	14.05	4	16.67	0.59	17.48	-0.12	-0.04
Annonaceae	1	0.08	*	0.97	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.00
Apocynaceae	2	10.38	0.18	4.82	2	15.75	0.32	9.89	2	31.38	0.54	16.31	2	16	0.22	10.6	-0.07	0.07
Araliaceae	1	0.15	*	0.99	2	1.25	0.01	2.9	2	2.375	0.05	3.04	-	-	-	-	0.05	-0.01
Bignoniaceae	3	7.31	0.32	5.67	3	5.25	0.18	6.76	3	9.875	0.23	7.92	1	2	0.03	2.55	-0.02	-0.01
Bombacaceae	1	1.23	0.19	1.95	1	0.25	*	1.33	1	1	0.07	1.91	1	1	0.02	2.08	0.06	0.00
Burseraceae	1	4.15	0.09	2.19	1	1.5	0.03	1.92	1	1.5	0.03	1.68	1	0.67	0.01	1.87	0.06	0.00
Caesalpiniaceae	5	16.00	0.48	10.04	2	25	0.62	15.27	4	17.75	0.54	14.12	2	7	0.19	7.31	-0.10	0.03
Celastraceae	-	-	-	-	1	0.5	0.1	2.23	-	-	-	-	-	-	-	-	0.08	0.01
Combretaceae	3	30.46	2.22	17.87	3	19	0.91	17.27	3	20.63	1.29	21.03	1	8	0.25	6.64	-0.14	0.10
Dilleniaceae	1	4.77	0.21	2.76	1	3.5	0.09	3.08	1	1.5	0.12	2.52	-	-	-	-	0.06	0.01
Dipterocarpaceae	2	168.46	10.74	79.14	2	3.25	0.13	4.54	2	2.125	0.07	3.15	1	0.67	0.01	1.89	0.11	0.20
Ebenaceae	-	-	-	-	-	-	-	-	1	0.625	0.01	1.24	-	-	-	-	0.08	-0.01
Ehretiaceae	1	0.23	0.01	1.05	2	0.75	0.01	2.73	2	1.25	0.06	2.83	-	-	-	-	0.05	-0.01
Elaeocarpaceae	1	0.23	0.07	1.25	2	1	0.05	3.14	1	0.125	*	1.01	1	1.33	0.01	2.15	0.06	0.00
Euphorbiaceae	11	26.77	0.49	18.12	7	32.5	0.49	22.48	12	29	0.56	25.33	8	123.33	5	101.17	-0.44	-0.32
Fagaceae	2	1.38	0.13	2.68	1	1	0.05	1.96	-	-	-	-	-	-	-	-	0.08	0.01
Flacourtiaceae	-	-	-	-	-	-	-	-	1	0.125	*	1	-	-	-	-	0.08	0.00
Guttiferae	1	3.46	0.11	2.1	1	0.75	0.01	1.57	1	2.125	0.03	1.86	-	-	-	-	0.07	0.00
Junglandaceae	-	-	-	-	1	1	0.03	1.81	-	-	-	-	-	-	-	-	0.08	0.01
Lamiaceae	5	31.69	0.93	15.12	4	11.5	0.28	10.77	5	50	1.47	33.37	3	9.33	0.25	10.2	-0.25	0.03
Lauraceae	3	2.77	0.05	3.65	1	3.25	0.06	2.7	2	10.63	0.25	7.37	2	6.33	0.09	6.18	0.00	0.01
Lecythidaceae	1	25.92	1.09	10.67	1	13.75	0.45	9.21	1	7.25	0.27	5.62	1	11	0.23	7.43	0.00	0.05
Lythraceae	3	11.92	0.22	6.24	2	11.75	0.21	7.73	2	12.5	0.5	10.31	2	18.33	0.47	13.74	-0.06	0.02
Magnoliaceae	1	0.31	0.08	1.31	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.00
Meliaceae	3	0.92	0.02	3.14	2	2.5	0.07	3.77	3	3.375	0.08	4.63	1	1	0.02	2.14	0.03	-0.01
Mimosaceae	4	5.00	0.3	6.01	4	9.75	0.78	14.55	4	12.75	0.77	14.76	3	10.33	0.41	12.13	-0.12	-0.02
Moraceae	12	30.62	3.94	33.07	8	16.75	0.83	21.97	13	32.75	1.43	35.44	9	24	1.32	34.79	-0.45	0.25
Myrsinaceae	1	0.92	0.01	1.19	1	0.75	0.01	1.5	1	1.125	0.03	1.56	-	-	-	-	0.08	0.00
Myrtaceae	6	14.92	1.39	14.24	4	18.75	1.02	19.35	3	10.75	0.46	10.31	2	8.67	0.49	10.74	-0.13	0.01
Papilionaceae	4	3.85	0.17	5.28	1	3	0.06	2.63	7	6.375	0.18	10.26	3	2	0.1	6.35	-0.02	-0.05
Rhamnaceae	1	4.23	0.06	2.08	2	4.75	0.05	4.32	2	5.625	0.07	4.23	1	1	0.01	2	0.03	0.00
Rubiaceae	5	8.62	0.35	7.95	4	9.5	0.22	9.59	5	9.75	0.17	9.3	4	3.33	0.06	8.04	-0.07	-0.05
Rutaceae	3	0.85	0.1	3.41	4	2.5	0.04	5.93	2	2	0.09	3.37	1	0.67	0.02	2.02	0.02	-0.02
Sapindaceae	1	0.08	0.01	1.02	-	-	-	-	1	0.125	*	1	1	1	0.01	2	0.08	-0.01
Sapotaceae	1	0.69	0.01	1.13	-	-	-	-	1	0.375	*	1.11	-	-	-	-	0.08	0.00
Saurauiaceae	1	0.38	0.07	1.32	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.00
Sonneratiaceae	-	-	-	-	-	-	-	-	1	0.625	0.02	1.33	1	0.67	0.04	2.21	0.08	-0.01
Sterculiaceae	4	7.08	0.13	5.82	4	5.25	0.11	7.44	4	10.75	0.27	9.5	4	5.33	0.16	9.66	-0.06	-0.04
Symplocaceae	1	0.15	*	0.99	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.00
Theaceae	1	20.31	1.3	10.26	1	85.25	3.65	58.42	1	0.75	0.03	1.47	1	9.67	0.32	7.83	0.12	-0.21
Thymelaeaceae	-	-	-	-	-	-	-	-	1	0.25	*	1.07	-	-	-	-	0.08	-0.01
Tiliaceae	3	9.38	0.15	5.45	2	8.75	0.16	6.41	3	13.13	0.19	8.59	1	9.33	0.13	5.9	-0.02	0.01
Ulmaceae	1	0.69	0.02	1.18	1	1.25	0.02	1.76	1	4	0.2	3.99	1	1	0.1	2.91	0.04	0.01
Vitaceae	1	0.38	*	1.05	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.00
Total	**105**	**464.74**	**26.23**	**300**	**82**	**336.25**	**11.48**	**300**	**105**	**333.90**	**10.77**	**300**	**63**	**299.66**	**10.56**	**300**	**0.00**	**0.00**

*BA value <0.01